[1644]

Ex libris Jonath.ⁿ Elmer

Elements of Physiology

Containing

1st An introduction giving a definition of the various constituent parts of the human body.

2dly A clear & distinct account of an animal fibre.

3dly A brief description of what the ancients called by the name of parenchyma.

4thly A full and compleat account of the tela cellulosa.

5thly The nature, seat, use, formation, secretion and excretion of the adeps.

6thly A compleat anatomical & physiological history of the arteries veins & lymphatics, the last being a translation of Dr Alex: Monro jnr's Essay proving the lymphatics to be a system of absorbing vessels entirely distinct from either of the former.

7thly The history of the circulation both of the blood and lymph in the demonstrative way, with the sentiments of the ancients upon the subject.

Hoc opus, hic labor est.

An animal body is composed of solids & fluids.[a]

Of the solids, a fibre is the most simple, & may be reckoned the same to the physiologist, as a line to the geometrician; all the other solids of the body being composed of fibres variously combined.

Membranes are compages of fibres disposed in a parallel direction, or the same plane, in the same manner as the threads in a piece of cloth.

Vessels are made up of membranes, either simple, double, treble or quadruple, convoluted into the form of a tube, that is pervaded by some fluid.

Arteries are made up of different membranes; they are a system of converging vessels arising from the two ventricles of the heart & distributed to all the parts of the

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[a] Solids consist of parts that cohere together so strongly, that the whole is scarcely removed by any force from its place, than its parts separated from each other.

Fluids consist of insensible parts having so small a degree of cohesion that they easily separate from each other & give way to a smaller force than will remove the whole body. There are various degrees of solidity & fluidity in the parts of the human body. Boerh: Instit: v: 1 p 80

body viewing to convey the blood through the whole system.

Veins are vessels similar in their structure & appearance to arteries, only weaker & less elastic, considered anatomically they arise from the two auricles of the heart (the vena portarum excepted) and distributed in the same manner as the arteries to every part of the body; but physiologically speaking, their origin is at the extreme ends of the arteries, and converging together, at length, terminate at the auricles of the heart, serving to convey the blood from the different parts of the body to the heart.

Lymphaducts are very small pellucid tubes, taking up any watery fluid in any of the cavities of the body, viz the Thorax, abdomen, Stomach, Intestines &c: or the Cellular membrane of any part of the body and conveying it into larger veins or the thoracic duct.(b)

Nerves are fasciculi of simple nervous fibrils united by cellular membrane, & included in a capsula: they arise from the brain & spinal marrow, & are distributed to every part of the whole body, being the organs on which sensation immediately depends.

(b) See a particular acct: of the lymphatics in vol i of Hunter's Comment:s

Muscles are evidently made up of fibres connected connected together by cellular membrane, as appears by examining them with the naked eye; they are the immediate organs of motion whether voluntary or involuntary.

Tendons & Ligaments are similar to each other, and supposed by some to be made up with the same fibres as the muscles, only closer connected together, so as to allow fewer globules of red blood to pass in between them, which makes them appear more white; others suppose they are made up of fibres different from those of the muscles, and as it were a middle kind between fleshy & bony fibres.[c]

Cartilages are smooth hard elastic substances found to be made up of fibres.

Bones are evidently made up of fibres as may be seen very plainly in the foetal bones of the head.

Of the fluids we shall speak in their proper place.

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[c] Dr. Hunter is of opinion that the fibres of tendons are different from those of the muscles & therefore not a continuation of them more closely compacted as is commonly believed, but distinct and only cemented on to the end of the muscles.

See his anatom. Lectures

Of a fibre

The best method of teaching physiology seems to be, to begin with the most simple parts, and gradually to proceed to the more compound; and as a fibre is the simplest part of the body, of which we have any knowledge, we shall begin there.

A fibre is the most simple part of an animal body, so small as not to be discerned by our feeble sight. For the smallest fibre we can discern with the naked eye, being viewed by a microscope, appears to be made up of a number of still smaller fibres.

All the solid parts of animals & vegetables, the fluids of metals, & of many other mineral substances, are made up of fibres.[a] The brain & spinal marrow, in short the whole substance of the body whether brittle, soft, hard or elastic, is made up of fibres, as the bones, cartilages, membranes, vessels, ligaments, tendons, muscles, parenchyma, hair, and nails.

A fibre is made up of earth & gluten. The earth is of the calcarious kind, & with it is mixed a small portion of Iron or of that kind of earth which by the union of the phlogiston may be converted into Iron & be attracted by the loadstone. The gluten serves as a bond of cohesion to the earthy particles, being interposed between them.

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[a] We are indebted to Bernard Connor in his history of Poland for this discovery

† When Augustus Cæsar paid a visit to Alexander's sepulchre at Alexandria, he found the body of the macedonian hero in its full dimensions, but so tender notwithstanding all the former embalming that Cæsar by touching only the nose of it defaced the whole figure immediately.

Lord Orrery's remarks &c. p. 109

That the particles of which these fibres are composed, do not cohere by mere contact, but by means of the gluten interposed, or a body which gives the particles a power of attraction, is evident, 1.st from their falling asunder when deprived of this gluten, by calcination, putrefaction, or long exposure to the air, for in a course of years when the heat of the sun has dissipated their moisture, dissolved their gluten, & the water washing through them has washed it off, they retain only their figure but fall to dust on the least touch.

The Emperor Augustus was an eye witness of the remains of Alexander king of Macedon.[x] The figure of that hero had remained even to his day, but being deprived of its gluten, shrunk into dust on being touched.[e] Travellers furnish us with an infinity of the like observations, as mummies & bodies of people dead many ages before; numerous examples of this kind are in the philosophical Transactions N.o 475.

2.dly From bodies deprived of their gluten, recovering their former solidity, on adding oil or jelly to them: this has been proved by the Experiments of Boerhaave, & hence of Buta in his dispute concerning the nature of bones; he says that calcined hartshorn boiled in oil recovers its former solidity

[e] Since the almighty can so dispose this frail machine of ours, that, in a moment, it shall fall to dust, is it not reasonable to suppose, that this same omnipotent being, can, by his energetic fiat, instantly order these particles to resume their former place, & thus recompose the animal body?

That there is gluten in bones, manifestly appears, from the experiments of Papin, who assisted the celebrated Boyle in making his chemical experiments. Kiell reckons this gluten makes up 2/3 of the bones of a foetus, about 1/2 of those of an adult, & so in proportion as they advance in years, hence we may account for the bones of old people being more hard & fragile than those of young people.

This gluten is insipid and inodorous as the white of an egg, in its natural state, and is said to be composed of water and oil. But there is likewise a great portion of air in this gluten, the property of which, unknown to the ancients, has been discovered to us by the celebrated D.r Hales.

This air is not only found in the fluid parts of the human body, having lost its elasticity & compressibility, w.ch may be recovered again, by means of fire & other causes which disengage it, & render it again like the atmospheric air; but, there is likewise a great quantity of air of the same nature in the firm parts of the animal body which can be set at liberty by means of fire or some dissolving liquor; its quantity is generally in proportion to the validity of the part of the body in which it subsists: when set free from bone it occupies 200 times the bulk of the bone itself, of which it

composed near ½ part of the substance; when set free from bartshorn it occupies 234 times its space.

This air, which is called by Hales fixed air, seems to constitute the primary bond, or cement, of the elements of bodies, seeing the elements do not separate from each other before the air is expell'd.

In what manner this air, imprisoned in bodies, parts w: its repellency which it changes into an attractive power, and so increases the cohesion between the smaller particles of solid bodies, cannot be referred to any known mechanic Laws, altho' we are certain of the fact by experience.

From what has been said it appears that a fibre is made up of earth, water, oil, air & a small portion of Iron, ℔ which when simple is so small as not to be discerned by the human eye. for the smallest animal which we are able to examine by glasses are made up of fibres of much less bulk without doubt than the animal itself.

The smallest elementary fibres, which we cannot examin alone, but by the eye of reason, are not made up of still smaller fibres, but being united with a number of like elementary fibres, go to make up two very distinct & conspicuous solid elements of an animal body, viz: a fibre vulgarly so called, & a lamina scale or thin membrane not further divisible by our senses.

℔ Vincentius Menghinus in the comment: of the academy of Bologna has provd that Iron may be found both in the flesh & bones of Animals.

The former is almost like a line, having length with very little breadth. The latter having very little length, has a manifest breadth.

By lamina we do not here meant, the large lamina of Bones, but the thin leaf like appearance of cellular membrane & such sort as the coat of the vitreous humor of the eye, which is of the most surprizing tenuity.

The former is the common fibre. endowed with elasticity, is flexile, & being extended, if left to itself, will recover its former brevity. The fine fibres even of the bony substance have this property as well as the fleshy ones; they are visible during ossification in fœtal bones especially those of the head. In weight they exceed water a little, as all the solid parts of an animal body do, unless they have undergone a degree of putrefaction spontaneously vinhsing in water.

*Two theories have been formed for accounting for the cause of solidity in the firm parts of an animal body. The first is that of Haller & Gaubius (as above) who imagin that the solids are an heterogeneous mass or aggregate & that their cohesion or solidity is owing to a composition of

* This is extracted from Dr Cullen's.

earth and gluten; this is presumed from a volution of the volid parts of animals whereby a gluten is separated from an earth which is left brittle; but this species of reasoning has no foundation, & they were led into this error by judging that the qualities of a compound are the same as those of its ingredients in a separate state: whereas it is owing to the whole conjoined, & is a result of the combination of the several parts, thus fusibility is a property of the mixture of lead & tin, & to be considered as a property of it as an individual whole, not to be imputed to the fusibility of either tin or lead, neither of which, in a separate state, have that property in so high a degree as the compound, of which it ought to be supposed only in the intermediate degree of tin & lead, were the property of the compound to be referred to its constituent parts. [g]

So the cohesion of bones & other volid parts of animals is the result of the several parts combined and not of any particular part.

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[g] Tin melts in about 400°: of heat in Fahrenheits thermometer, Lead in 600°: when combind they fuse with less than 400°: of heat.

But should we allow that the solidity of bodies de-
pend on an earth united by a gluten, we may then ask
on what does the coherence of gluten depend? they answer,
on the earth which it contains. So earth owes its
consistence to gluten, & gluten its consistence to earth —
pretty reasoning indeed!

The second theory is, that the firmness, or what is
called the cohesion, of solid bodies depends, on the com-
mon principles of salt, oil, and earth, which are obtain'd
in every chemical analysis. This doctrine is equally
fallacious with the former, because we are sure these
three are not the only parts of which a body is compos'd,
but should we grant that these three are the only
parts of solids it would still be objected that much
depends on the proportions of these to each other, since
the same are obtain'd from all vegetables as well as
animals, & the cohesion is so very various in different
animal & vegetable substances.

From the two kinds of ... Fibres of which we have already treated under the name of fibres commonly so called, and Lamina; is composed that large portion of the human body which is called by writers the cellular membrane.

In some places the fibrous texture is predominant as in the fibrous cellular substance of the long bones, & in the loan vagina or sheathes of arteries, such as bind the carotid artery.

The lamina are found in the greatest number in the epiphyses of bones, in the vitreous humor of the eye, in the interstices of muscles which distinguish the bundles of fibres from each other, also in the lungs, in the cells or tunics of the intestines, & in every part that receives fat.

Whether composed of lamina or fibres, this cellular membrane is a net-work, composed of elements variously conjoined, so as to intercept little spaces between them, which are long as in the sheaths or coats of arteries & veins & are broad wherever there was a necessity that a great quantity

of fat should be accumulated as about the Kidneys; & which are very small & scarcely visible wherever the cellular substance is thickned into a membrane.

The membrana adiposa, the common tunic of the muscles, the membrana vaginalis & dartos, all of them, so named by the ancients, altho' they thought otherwise, are of a fibrous texture, the stamina whereof pass thro' bodies of fat.

The extensiveness of this cellular membrane in the human body is very great. In the first place it is found, under the integuments of the body, between the skin & the muscles. In the 2d place, this cellular membrane, surrounds those large membranes, which contain the viscera, as in the external surface of the pericardium & pleura, also where the pleura forms the mediastinum.

It surrounds the peritoneum externally, as well where it is conjoin'd to the Diaphragm & muscles of the abdomen, as where it covers the bladder, uterus, & intestinum rectum: also where the peritoneum covers the kidneys & vertebræ of the spine, as well as where it is duplicated forming the meuentery

covering the intestines & forming the ligamenta lata of the abdomen, which sustain the uterus in women, & the spermatic vessels in men. It fills the interstice of the two lamina of the peritoneum every where, that this membrane lines or covers any of the viscera, as the intestines, stomach, & gall-bladder. It is even finer than the finest web, over the pia mater of the brain & cerebellum, where it is called arachnoides. All the proper tunics or coats of the bowels, the heart, lungs, kidneys &c: are connected to the parenchymatous substance under them by means of fine threads of cellular substance. It sheaths all the fibres, bundles of fibres, & bellies of all the muscles; as well as the finest threads of fibres: these sheaths are the more tender & subtile in proportion as the fleshy fibre is to which it surrounds.

No instance can be given either in man or any other animal of any fleshy fibre free from cellular membrane.

All the vessels in the human body, arteries, veins, and nerves, are covered with a cellular vagina, the most remarkable of these sheaths are those which cover the genital

and hepatic vessels having the name of a capsule.

Again, wherever several tunics, laid together, go to form one hollow tube, there are so many cellular net-works between them, which distinguish these coats from one another, at the same time that they unite them; examples of which occur every where in the coats of the arteries, veins, intestines, stomach, urinary & gall bladder &c. The interior structure of the glands, shew the parts to be connected by means of this membrane, into acini. This membrane likewise serves to fill up any vacuities in the body, as the cellular texture within the bones, & which receives fat that has the name of marrow, of the same kind is that spungy texture of lamina within the cavernous bodies of the penis & clitoris, & which on particular occasions are gorged with blood.

A similar structure, but of a more tender kind, contains air in the lungs, water in the navel string of a foetus, & a very thin limpid water in the cells of the vitreous humor of the eye. These, like spungy cells, fill the unripe stalks of shoot plants, which in the adult plant is chang'd into

into a membranous or woody substance.

So extensive & universal is the cellular substance, w^ch is patent however in all parts, insomuch that air, or any liquid, extravasated in any part of an animal body may, by means of these cells, find a passage to every other part however remote.

Air forced thro' a wound under the skin into the cellular membrane whether designedly or by chance will quickly pervade the whole surface of an animal body, and will even penetrate into the interstices of muscles, giving a deceitful appearance of fatness, which subsides after a few days the air being rendered effete. On this footing cheats are often practised by the Butchers, in blowing up their meat. Air often escapes from a fractured rib pierc-ing the lungs into the cellular membrane, forming a tumor, which is called an Emphysema. [h]

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[h] See an acc^t of an emphysema from castration by D^r Monro in the medical Essays vol: 5, from a broken rib in Cheselden's Anatomy p 130 & by D^r Hunter in the 2^d vol of lond^n medical observations & Le Dran 25^th observation.

In an anaivarcous Dropsy, the water diffuses itself throughout the body, often enormously distending it.

Abvcesses, or collections of pus, and of a like nature, the pus formed by the suppuration of a bowel, or any other part, sometimes diffuses itself thro' the whole body; Ther abscess in the kidneys, or loins, has made its way along the cellular membrane to the groin. From a suppuration of the parotid gland, the matter has made its way along the neck, & arm in the course of the cellular membrane between the muscles to the bend of the elbow, & there destroyed the ligaments of the joint, so as to produce an Anchylosis.[i] Many similar instances might be adduced to the same purpose.

As we have shewn how extensively these cells communicate with each other we may readily understand how any matter effused in those spaces may move from

[i] See Vanswietens commentaries vol 3 p 450, See another another case p 476 also Boerhaave's Institutes vol 3 p: 278

from any one part to any other upon the accession of motion.

We are told by Thevenot in his travels, that the Arabs know in what manner, by puncturing a particular part in the Brotheo-Camelus, a species of Camel, in which the adeps or fat is very fluid whilst alive, to collect & make all the fat of the body run out at one wound. The like accounts we have of the exit of pus. Aegidius Wallis, who wrote of revulsion & derivation, tells us, of a woman who spit up purulent matter in whom a Seton being cut on the back of the neck, her hectic symptoms, which proceeded from the absorption of pus into the blood, wholly remitted, but upon drying up the Seton they again returned; this shews how useful Setons & blisters often prove in consumptive cases.

There are very frequent examples, which prove the same doctrine, in Hydropic patients; How often does a wound or incision in a very remote part draw off the water of a dropsy widely diffused? Geoffroy tells us of a hydropic patient swelled up to the very eyes, from whom every drop of water was drawn off by scarifying his legs. Sometimes the

chin in the feet of dropsical persons has burst of itself, & all the water drained off, so as to cure them entirely, frequent examples of this kind are met with in practice.

Raimondus tells us of an Hydrops pectoris in which, by scarification in the feet, eight pints of water was drawn off. Indeed the water frequently passes thro' these cellular spaces spontaneously, so that after a dropsy of the breast the Scrotum has began to swell, & the water afterwards descending of itself has made the feet to swell, wch bursting, has affoded an issue, by wch all the water has been drained off.

Other extraneous bodies have likewise changed their places in a wonderful manner, by means of the cellular membrane. These being introduced by a wound into the body in one part, have made their way out in a very remote one, from that by which they were introduced; such as pins, needles, and bullets from gun shot wounds. Thus I have heard of a needle being swallowed, & afterwards cut out from one of the fingers; of a beard of barley that was swallowed & made its way thro' the loins, & have myself seen a needle which had been swallowed & made its way into the bladder

where it formed the nucleus of a stone & was cut out.

Baglivi mentions a bullet that went in at the breast & came out at the buttocks by an abscess formed in that part.

The usefulness of this cellular membrane being so universally diffused thro' the body must be very great. Its principal office is to give a due firmness to all the parts of the animal body, so as to answer the wise designs of our great creator; should any considerable nerves, muscles, vessels or membranes, be deprived of this web they would soon give way & be over stretched. The vessels would not be able to resist the fluids impelled thro' them with due force, they would yield & be distended so as to produce Aneurisms & varices of the arteries & veins. A nerve deprived of it would be stretched to too great a length.

The same web is of use to connect membranes together, to give strength to the intestines, stomach, & to all the receptacles of the body, which might from a faulty laxness, yield to every impulse of air & humors, unless this web had united the muscular to the nervous & external coats.

If the peritoneum was not connected to the diaphragm, the sternum, & mediastinum, as well as to the tendons of the great abdominal muscles, by means of the same, the viscera could not be firmly contained in it.

It is this which unites the acini of the glands & of the viscera, & produces in them a due degree of cohesion, which would be too hard & solid if this web was scanty or bare, & on the other hand, might become too soft if it was in a very great quantity, & too much filled with fat.

2dly As it procures a proper solidity of parts, so it procures that due mobility which is connected with sufficient firmness, as it is composed of threads both elastic and extensile, it causes the parts connected to move on each other with some freedom & not to coalesce into rigid bodies; whenever the muscles have lost this subcutaneous net-work they grow firm to the skin, & loose their motion so as to bring on a sort of Anchylosis or stiff joint. The glands also, when this substance becomes indurated into a scirrhus, with the contained humors, become immoveably united with the skin & loose the freedom of motion they had in a healthy state.

3dly The figure & flexion of the limbs are determined or limited by this cellular membrane. The vesiculæ seminales by means of it are puckered up into a proper sphæroidal figure having various apartments to contain the Semen. Without this it would appear like a gut with blind pouches or cæcum appendages. The gall-bladder is kept in its place by means of this web, & the valve of the colon is formed by cellular threads connecting the ileum & colon together & so preventing the return of the faces, which it would not do, if these bands were cut asunder & the valve destroyed

The flexion of the carotid artery, as it enters the lower part of the cranium, is owing to the cellular membrane which, if destroyed, the artery would be long and strait which must prove detrimental to the passage of the blood through it.

In short in whatever part of the body, that it now is, should it be wanting, the true figure of the parts of the animal body would be proportionably destroyed

Of great & excellent use the use of this substance in the body; so justly does it lay claim to our notice & attention. So great a part does it constitute of the human body!

Besides cellular membrane, some suppose there is a certain unorganized concrete, through which the vessels pass, in many parts of the body, as in the viscera, bones, &c: w: ch the ancients called parenchyma; imagining, it to be an effusion or evasation of blood, concreted into a solid mass. It seems probable all the solid parts of the body were originally formed out of this unorganized chaos, for we see fibres & membranes are often preternaturally formed out of the blood, thus a fibrous & even membranous substance has been formed between the pleura & lungs from an evasation of blood by a violent inflammation or other cause: the parts of a fœtus are, at first, a mere jelly, which afterwards grow more & more fibrous & solid: blood stirred round with a stick while warm, collects a fibrous elastic substance about it: Bones are likewise formed out of this substance, & bones by analysis appear to be of the same original for by digesting them in acids they become soft & pliable.

This wonderful & amazingly grand machine of ours, seems then, to be formed originally by an aqueous fluid, & cretaceous earth, uniting together into a filamentary concrete, viz: ch, by a particular mechanism, the noble contrivance of the supreme omnipotent, is form'd into cellular ment: ane this by suction and cohesion forms membranes, & afterw: vessels, and all the other solids.

From the cellular membrane we proceed to speak of the adeps or fat itself the seat of which is in this membrane.

As there are both fibres and lamina in the cellular substance, so there are also small spaces intercepted between those fibres: In these places a white liquor is poured out between the lamina to prevent their growing together and taking on them a morbid hardness.

In a very tender & young fœtus e.g. one of 4 months old, there is no fat to be found in the cellular spaces: the whole omentum is pellucid, but there is a skins of jelly interposed between the muscles & skin. In the smaller cells there is an aqueous fluid which readily evaporates & is mixed with a portion of oil. This is the vapor of Hippocrates which he called spirits.

But in the omentum of a fœtus, more advanced, & in the rest of the body of the tender animal, white globules appear, filled with a friable fat: these globules are smaller in proportion as the vessels are more tender. But fœtuses are never so fat as adults, so that there is less fat also in their hearts.

Of the adeps

When a child is born, in the first years of its infancy, it is very fat. There is a much greater quantity of adeps under its skin than in a riper age, in proportion to the muscular flesh, & it is very white & soft.

Another age of fatness is about the 40th. year, & after, which continues to old age, when it diminishes & almost wholly vanishes at length, giving way to a reddish gelatina the place which it had occupied in the fatus.

Seat of the adeps. In some parts of the body there is never any fat. The brain & Cerebellum have no fat. It is but in a small quantity in some wrinkles or folds of the body, in which there is a depression between two risings, as where the top of the thigh is joined to the Buttocks. It is but sparingly placed between some broad muscles which are kept in perpetual motion as between the rectus & crural muscles, the gastrocnemius & soleus & others of the like kind.

There is very little adeps in the external surface of the hairy scalp, the forehead, eyelids & Scrotum.

It seems to be wanting where compression would be

be attended with danger as in lungs & brain, & where there is a necessity of the sense of feeling being acute, as in the glans penis & in the clitoris.

Fatt is found where the vessels are small, the muscles few, & the friction constant.

It accompanies the large muscles in great plenty. It abounds about the anterior part of the abdominal muscles, as well as about the interior & upper parts of the thighs, and on the breast.

A great abundance of fat is placed under the gluteæi muscles, but only in the human body, nor is there a mark of greater distinction between a man & an ape than the leanness of the natees in the latter.

A very large quantity of white & soft adeps is placed all round the gland of the female breast, which forms that pleasing hemisphere. It is abundant in the palms of the hands & in the soles of the feet, but the several portions of it are firmly kept in their place by firm cellular fibres which separate one from another

Very large & soft portions fill up all the orbit of the eye, which the muscles & bulb of the eye leave unoccupied

and that in every animal whatever.

It is in greatest plenty about the Kidneys, both before & behind. This is generally hard & will bear to be cut being best known by the name of tallow.

Lastly, large & long portions of fat are stored up in the cavity in the middle of the long bones.

Adeps quid sit?

In the human body, & in that of quadrupeds that feed upon flesh, the adeps is soft & certainly is to be esteemed a fluid as long as the animal lives. In live dogs it is often seen hellucid & fluid in the omentum & heart, as well as in the ovaria & other membranes of animals that have hot blood. It is very soft in the human body, about the spinal marrow, & is bloody & fluid in the epiphyses of bones.

It is the nature of adeps when fresh & soft to yield to the touch with a very slight spring. Being interposed betwixt bodies moved upon one another it diminishes the friction, & being unctuous it adheres to bodies that are not watery. It cannot be dissolved in water unless by

by much attrition & the force of fire in which it melts.

A chemical analysis shews that in the fat of man, & of animals like to man, as well as in the tallow of ruminant animals, there is water, but in small proportion, next inflammable oil in a large quantity, as well as an active empyreumatic liquor of an acid quality, so that the adeps retains many vestiges of a chyly & milky nature & in this agrees with butter

It now becomes our business to enquire from whence the adeps is produced. This enquiry belongs properly to the doctrine of Secretion which could not yet be sufficiently explained in order; but the experiments & observations which relate to the explanation of this subject are so simple that we may as well finish here the whole history of the cellular tela & adeps

The cells which are mentioned to be intercepted between the lamina & fibres of the cellular net-work, & which serve as receptacles to the fat are of various figures. They may be seen every where in the human body but best in the corpora cavernosa penis, & in the little cells of the vitreous

humor of the eye & especially in the inflated spongy texture of the navel string, lungs, stomach & intestines, because when empty they are best discerned by the eyes. They are evident in the larger fishes whenever the receptacles are void of fat. The figure is roundish & open on every side.

Marcellus first described egg like blind ampullæ, appended to the extremity of arteries, collected into globules of a vascular net-work appearance. Gruetzmacher too has represented in two figures the coats globules of marrow & the larger trunks of arteries running thro' the intervals of its globules & cells & their smaller ramifications w.ch are spent upon the cells. This is all we have certainly known of the matter on good authority; although many conjectures have been offered on the subject.

Malphigius suspected that there were glands for the secretion of fat & in this mistake he has been followed by many; as several persons had discovered the excretory ducts of the larger glands & Malpighus himself those of lesser follicles, this analogy improved on that great man

and made him assign ducts proper to the fat. He had mistaken certain oily or fatty lines proceeding from the adipose tria of the omentum & accompanying the red vessels in their course to be true excretory ducts which arising from the arteries of the omentum conveyed the fat into the cells: this he confessd to be only conjecture & this conjecture has been since refuted by the industry of more modern anatomists. Malpighus himself after more mature consideration of the subject gave up his former opinion of these being ducts, & the same Theory has been refuted by the celebrated Morgagni. It is easy enough to see into the mistake of that great man from the cellular tria which in a living animal are filled with a fluid fat.

Let us now enquire into the truer secretion of fat viz.t in the arteries of the human Body; we are convinced that there are pores thro' their whole length which are not visible to the eye, or that there are short excretory ducts which however are not conspicuous, which open

of the adeps

from the cavity of arteries into the cavernous cellular.
Experiments render these pores conspicuous, for a liquid of
any kind being injected into the arteries whether it be
a watery, gelatinous, adipose or vaporaceous liquor finds
its way out through the whole length of the arteries & is
effused into the spaces of the cellular substance. water
whether hot or cold soon passes out from the artery into
which it had been injected with a syringe into that
spongy web & sinks that way much more readily than
from the artery into the veins, so that to succeed here-
-in there is no need of tying the veins.

A singlass dissolved in water or in a weak malt
spirit tinctured of some bright color & warm, runs imme-
-diately from the artery into the cellular membrane under
the Skin, or into the cellular interstices of the membranes
of the stomach & guts; this prevents the system of
vessels being properly filled with a fine liquid, but gives
a most beautiful preparation of the nose gut & stomach
when the vermilion color effused into the cellular substance
is seen thro' the fine pellucid internal membrane. Even

melted Tallow being somewhat forcibly injected exhales the whole length of the arteries in exact imitation of the natural coat of the adeps. which may be seen disposed in similar strice in the whole course of the omentum however long, and of the other parts of the animal body.

This excavation proceeds from vessels that are entire & which might be easily distinguished if they were ruptured because all the injection would be collected & stagnate about the wound in a compound mass. whereas on the other hand by exhaling it makes a line parallel with the arteries every where of the same thickness, nor running more out of the extremities, than from the simple trunk without branches

The air does not so readily pass through the course of the fat as the adeps itself.

The blood vomitorius passes through the same way.

In the bodies of criminals that have been strangled and afterwards dissected, or who have died by a most violent inflammation, there are to be seen frequently in the membranes of the stomach & intestines, red, brown & almost black spots the whole length of the artery evidently caused by the blood

effused thro' the artery into the cellular substance which surrounds all arteries.

In fatal peripneumonies the blood often exhales into the air vesicles of the lungs & makes them so heavy as to sink in water; this effused cruor being out of the laws of the circulation with the passage of the blood.

The petechiæ seem to be nothing else than the blood exhaling into the cellular spaces under the skin.

The anthrax or carbo is the same but a more violent disorder, for in it the blood being extravasated into all the cellular intervals of the part affected even to the bone fills them with a black color.

These happen from entire vessels no way broken for that is a rare disease.

Daniel Schlüting has shewn in a masterly manner that inflammations often arise from blood impelled into the cellular substance; and Vanswieten asserts that great inflammations arise from that cause. In continual malignant fevers Cleghorn describes the

adipose

adipose parts of the body the mesentery, omentum & colon to be livid from an effusion of blood.

To a like event we may refer those exudations of blood which were so often observed by Boerhaave arising from the too much driving & whipping of animals fatigued with running. To this may be added Sewenhoec's testimony of blood exuding from the arteries.

The readiest passage then from the arteries is into the cavernous cellules; but in a sound animal the adeps is in readiness, for the chyle the greatest part of which is buttery evidently swims along in the blood. Morgagni gives his unquestionable testimony of cases in which true adeps has distilled from amputated vessels in drops, and Malpighius tells us of his seeing the fat flowing in the vessels of frogs. If then adeps flows along with the arterial blood, and if along the whole length of the arteries there is a very free and open way into the circumjacent cells, if moreover (which shall be shewn in its proper place) the adeps is carried spontaneously to the sides of the vessels, there is no great

obscurity in the secretion of fat.

As the passage of the fat to its receptacles is but short so it is soon performed: Ortolans those small birds so much admired as a dainty by the great, grow fat in one day;

Larks which are very thin in the day time grow fat at night. Swine after being very hungry will grow all fat in three or four days; and young people who have lost their plumpness of flesh & shrunk by sickness, soon recover it again when they grow well.

What is required to collect fat } Rest both of body & mind is necessary in order to collect the fat in its cells. Bodies exercised with labor & fatigue do not grow fat; whether of man or beast.

Horses that are kept lean by continual riding & fatigue, soon grow fat when stabled up in the winter. It is well known that old oxen which are kept thin by plowing soon fill up with very savory fat when they have been sent a while to good fat pasture. Geese that are kept quiet, blinded, & have their legs broke acquire an enormous bulk by feeding, & pidgeons grow very fat.

Of the adeps

Mountain mice & bears become very fat in the winter with little or no food, as according to Ray & Aristotle they sleep almost perpetually. That them may grow very fat it is necessary they should sleep a good deal & for that purpose cockle should be mixed up in their food

all those things which lessen the motion of the blood, the health still continuing, will procure fatness. The age of forty & fifty years favors this because the pulse then beats slower, & the powers of the circulation become more languid or less rapid: on the other hand care & labor produce leanness, & those become the fattest who are least disturbed with strong passions of the mind. On this depends the vanity of Caesar that he apprehended nothing from the fat & bleak, for the subtle tyrant meant by this varying, that such people would not grow lean under care of the common wealth or with ardent desires of liberty. Baker speaking of the affections of the mind observes of Swift, that as long as he exercised himself in disquietude & anger, he was very lean, but became very fat

fat when the powers of his understanding were at length quaitly weakened.

Venesection often contributes to fatness, because it lessens the stimulus of the heart & weakens the whole ma-:chine; by this means they fatten calves in England. likewise from the same reason castrated animals grow fat, not because the nutricious parts of their food cease to be discharged as before, but because their bodies are u-:niversally less strong & robust, & are stimulated by a less powerful motion of the blood, which is proved by comparing animals that have been cut with male animals of the same species which have not been cut, one is fiery the other gentle and mild.

Lastly even in one & the same animal the fat is collected in that part of the body kept free from friction & agitation. Adeps has filled up the place of the Spleen cut out from a dog & of the testicles cut out of men

We may here observe that farinaceous substances and milk in a particular manner contributes much to fatness as they accumulate large quantities of the matter thereof in the blood.

Of the adeps

2dly As there is a ready passage for the adeps from the arteries into the cellular membrane, the same is true of the veins. For indeed as the fat is deposited from the arteries so it is necessarily taken up again by the veins. Anatomy proves these passages as well as the former. For in like manner a liquor injected into the veins exudes thro', & fills up the spongy cavernulæ, as water Quicksilver &c. This often happens in injections, thus S. Hales having injected water into the veins of a dog beheld the cellular spaces & salivary glands turnify: thus water injected into the adipose cells of the marrow sometimes issues out by the veins.

That there is a return of the adeps into the veins is proved from numerous examples. In the first place, as violent motion of the muscles carries off the fat in all animals, so likewise it does not suffer it to remain long in the cells. The muscles swelling in their action squeeze the cellular substance in their intervals & push the fluid adeps back through the open orifices into the veins, w^ch in this state of the circulation convey the blood back quick

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to the heart & thus favor its resorption. Very quick is the resorption of the adeps into the blood, the fatness which Larks acquire in the night they loose again the next day & look worse than before if we may credit Stahl. The Bradipus or Sloth we learn from Dampiers voyage round the world, when it has come down from a tree quite fat from the very little fatigue of creeping from tree to tree wastes away into the form of a Skeleton.

The flesh of oxen in Brazil drove from remote provinces of Pernambuca to the bay of all Saints is greatly emaciated; & there is no marrow at all in the bones of the oxen and sheep drove from the provinces of France to Paris, but this is quickly supplyed again as we learn from the testimony of Rohault, Lemery & Senac. The male cattle often loose the marrow in their bones from their encounter with the females. Calius Aurelianus recommends to overcome obesity by motion only. I knew myself an instance of an english Gentleman at Rome of the name of Martin who had by walking & great

exercise chiefly, with some restraint laid on his appetite & a liberal use of vinegar, brought himself from being of a most corpulent size down to that of a slender & genteel man, & by the same means he was able to continue in that state.

The cellular substance is quite empty of fat about the Kidneys of those animals which are swift in their motion. By much friction we read of very big bellies & an unwieldy quantity of fat being brought down.

That there are other causes of the fat flowing back again into the blood than muscular action is not to be denyed: and muscular motion itself does not bring down fat animals merely by squeezing the tela adiposa alone, seeing the very marrow disappears from the bones, to which muscular action cannot contribute; but the increased transpiration & sweat seems to be effected by the same motion in fevers as in violent motions of the body, hence the loss of other parts than the adeps lessens the mass of blood so as to dispose the fluid adeps to flow into

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a laper part which gives lefs resistence, as the veins in the vame manner that the dropsical waters are carried into the blood after violent purgings. Venesection in fevers has likewise some effect this way of producing an inanition. Fevers it is well known emaciate the body very much, & all that is lost from the weight of the body is adeps. If we compare Ruysch & Sanctorius we shall find that the body of an adult is 30 pounds lighter thereby, & 50 lighter by a Salivation according to Boer:haave, ans 80 lbs lighter by the small pox if very cor:pulent before. The body of a man who had dyed of the small pox being examines not the least quantity of adeps was found in the whole body. In colliquative & hectic fevers the adeps is melted down as it were, and wholly consumed.

But other large diminutions of the natural humor exhaust the fat, & especially from the use of Guaiacum in decoction; but it is observed that after the body has been much emaciated either by this medicine or the use of mercury the former fat of the body is quickly restored.

And

And even without the prevence of any disease & without any very violent circulation of the blood in a very healthy body, the fat may return into the blood after consumed; for a too great fatness has been brought down only by the use of acrid food & food generating fat but in a small quantity. Galen cured a young man of too great fatness by means of Theriac, Salt, walking, and friction. Fatness has been cured by the constant chewing of Tobacco. Many persons praise vinegar & acids for this purpose, but it is a question whether it is prudent & wholesome advice which they give? For Haller mentions his having seen the stomach swell into a scirrhus bulk from the abuse of Vinegar and spirit of Vitriol. Others mention the lungs becoming tuberculous from the same cause. Canary birds when too fat, by giving them rape seed are freed from that w:

Lastly, fasting consumes the fat: & then matter only is wanting to supply new fat in place of that which the blood continually resorbs. Snakes by constant

fasting become lean. Masses of fat is found in the Chameleon Lizard & frog in the autumn, of which they are quite empty in the spring. A boy who was much neglected & to whom little food was given was reduced to the leanness of a skeleton. I do not infer from thence that the adeps absorbed is nourishing It is sufficient for the present purpose if it be allowed to be reassumed into the blood whatever purpose that may answer. Roesel de Rosenhof a man very expert in making experiments & who denys that adeps nourishes the body, yet asserts in his history of frogs, that it both diminishes & is again increased in the body.

When the fat is exhausted especially by disease, the same kind of gelatina almost succeeds, as was contained in the receptacles before the time when the fat was first introduced. The cause seems to be a languor of the chylipoetic viscera the water & vegetable gelatina from that defect still retaining their nature, and in the return of the vapor to the larger vessels being intercepted which vapor being retained in the receptacles stagnates & distends them.

Of the adepts

Use of the adepts. It now remains that we consider the use of the adepts. That these are very important will appear probable at once to him who considers how extensive it is diffused thro' the different kinds of animals, that it is found not only in men, in quadrupeds, birds, fishes, & insects, but that even the very small flies or gnats are not devoid of it. It is found as extensively as the muscular system itself.

The principal advantage it gives to the animal body is the mobility which it prevents amongst the neighboring parts of the body: for friction excited between any two solid bodies whether ropes, leather wood or metals cannot be removed more effectually by any means than by the interposition of oil whereby the asperities or inequalities seem to be smoothed which stand out on the surfaces of almost every body so that from filling up the little hollows which are placed between the risings the whole surface can be changed into one plane. Besides animal fibres easily grow rigid & change into a dry friable nature. But now the interposition of oil lessens the friction of fibres

fibres in contact with one another & vmears them all over with a warm bland substance. In the vmaller mus=cles a gelatinous vapor performs the vame office nor are any parts found to be moveable upon one another but where vome liquor is interposed.

Moreover the adeps keeps up the proper distinction between the adjacent parts & members of the human body. It verves as a medium to prevent their growing together, for if the interposition of this should be abolished all the parts would firmly unite in one rigid mass, the skin with the muscles & the muscles with each other & with the periosteum, & the motion of the limb would be quite lost.

From the loss of the adeps then it appears how great its use is in the body, seeing that if the flesh was to grow to the bone either the motion of the limb would be lost; or at least a kind of anchylosis would ensue if a large abscess should happen in the plexus of the limbs. From a wound in the part the duodenum has grown fast to the peritoneum & the Liver to the diaphragm. The omentum being

being destroyed after wounds, the intestines adhere to the peri-
toneum & grow to each other; the same bad accident has hap-
pened in a lean body, the fat of the omentum being consumed
and when the omentum has been dissolved or mortified the
stomach, liver & spleen have all grown together.

From the same wise intention, & to prevent the cohesion
of parts which are necessary to move upon one another, a
fat exhales from the surface of the mesentery, mesocolon,
omentum & perhaps likewise the fat of the breast. It mixes
with the exhalent liquor poured out into the cavity of the
abdomen & thorax to facilitate the motion of their contents.
The soft & slippery nature of the intestines and all the
abdominal viscera appear to be preserved by that safeguard.

The fat under the skin exhales thro' the large pores
so very discernible in fishes & not quite obscure in men and
passes out with the hairs to the exterior surface of the skin,
& preserves it sleek & safe from the sharp air: for such is the
violence of this element, that it dries & obstructs all the animal
membranes except the Epidermis, & makes them hard like horn.

& deprives them of their humors & life. The coldness of the air is not better averted from the skin than by being smeared with some oily unctuous, as we learn from experiments that imitate nature. Furthermore the adeps fills up very many intervals in the muscles so that a firmness may be given to those parts that would fluctuate without that, and at the same time whilst the soft adeps yields, those parts can be moved & dilated without any obstacle. As for example in the orbit of the eye, seeing the eye and its muscles do not fill up the orbit, were it not for the cushion of fat beneath the eye would be quite flaccid, but if it was quite large enough to fill up the socket without the fat, it would be squeezed & too much compressed in its motion by the bony sides.

A large quantity of fat being placed under the skin of the nates in men serves to keep the glutei muscles from too hard pressure or friction, & being interposed between the rectum & internal obturator muscles it fills the bottom of the pelvis in such a manner as to yield to the pressure of

the faces in the rectum & being squeezed pours out a soft unguent, lubricating the sphincter & levator muscles so as to facilitate the discharge of the faces; besides it takes away the otherwise disagreeable figure of a skeleton by filling up the chasms with a pleasing fulness. Thus the fat lodged amongst the muscles of the cheek gives them a healthful & agreeable look, whereas when the fat of the cheeks is consumed, frightful hollows are sunk in the face; to the same cause may be referred the ghastly hollow eyes when the fat of the orbit is wasted by a hectic fever. The fat renders the skin pellucid where placed under it, gently supports it & gives it a white appearance; hence children look so white, hence those parts are the whitest, which have the most fat under them; hence the skin of young girls fades away to an olive color when they grow hard.

Let us now enquire what is the use of the fat being absorbed. There are some who doubt whether being restored into the blood it can afford nourishment: & whether an animal can live on it's own juices. Most of the ancients

physiologists on observing that animals which sleep in winter are fat in the fall but come out of their holes lean in the spring fell into the opinion that this oil being absorbed nourished them, & supplyd the vacuity of blood which follows on fasting, & lastly that it afforded a gluten which proved a restorative to all the solid parts. Others have rejected this kind of nutriment & not without suitable reasoning on the subject. For animals that lie dormant all winter evacuate no faces, perspire very little, & the circulation of the blood is so moderate that they are quite cold. If they consume nothing where is the necessity of a new supply? Then it has not appeared to some of the greatest men that the adeps when returned into the blood is of a nature to preserve the bland temperament thereof seeing it excites very distructive fevers in men & horses that suddenly grow lean from violent motion of the body; and there it seems to suspect that if it was so fluid & so agitated as to be absorbed, it would grow acrid, as boiled oil becomes acrid. And indeed so far from being wasted in sleep the adeps

seems

seems there to be accumulated for the motion of the blood is slower in proportion as sleep is protracted. Nor is it sufficiently certain that animals do come from their winter hiding places so lean as has been generally imagined

We may here consider what are the uses of the marrow. In the first place, there is not the least doubt of the marrow being absorbed thro' the pores into the hard bone & that it emerges from its cavity to the very surface; for that rout the marrow describes in the dead bone & colors the bones with a penetrating & rancid yellowishness, & exudes from the ends of the lamina of bones in very manifest drops. The utility of this absorption seems evidently to consist in its oiling the fibres & lamina of bone to lessen its brittle quality, & to give it some degree of flexibility.

Another use of the marrow seems to be that it may transude thro' the cartilaginous crust that lines the epiphyses that it may mix with the fluid of the joint & increase its oiliness

Having enumerated some of the uses of the fat, let us now explain some of its diseases.

Of the adeps

Adeps has its proper bounds which some celebrated men have fixed to eight pounds in an adult body. Men however sometimes exceed that quantity & accumulate vast quantities of fat from rich living & from too much ease & indulgence of mind & body, especially if that was preceded by a laborious kind of life, as in oxen taken from the plow & sent to rich pasture to fatten. We have an illustrious instance of this in Plutarchs lives, of Demetrius who in his better years had merited the name of Policrates, being taken prisoner & kept in close custody, but being supported with a royal apparatus, he grew so fat, that he died from that cause alone, in a few months.

There is mention made in the philosophical transactions of fat in a man collected under the chin 6 inches thick; so that the story of Dyonisius the tyrant at Heraclea has nothing which exceeds probability in it, who it is said, was so fat & heavy a sleeper that there was a necessity of running sharp needles into his flesh to wake him. The cellular substance was insensible and

the needle did not excite pain till it had got thro' the fat to the fleshy part. The nerves in the cellular membrane were separated perhaps by the quantity of fat interposed, & it may be, that being covered so much with fat their feeling was more blunt.

One very great fault of too much fatness or obesity is that it blunts the acumen of the nerves if it is collected in a part where the nerve is required to be more acute, as in the penis. If it is heaped up between the muscular fibres it separates them so that they almost vanish, being torn from their parallel, & passing thro' too soft a medium they cease to exercise their contractibility. This & the impotency of the muscles to support the too great weight of the body are the conjunct cause why those become so unfit for motion who labor under a load of fatness

Those who are fat have less blood, because all that fat is drawn off from the mass of humors contained in the vessels which is collected & stagnates in the cells. Too much fat compresses the vessels & particularly lessens the

diameter of the veins as Surgeons too often experience when about to open a vein in the arm of very fat women. By how much more fat animals have, says Aristotle[1/2], so much less blood have they, as well as other good writers on natural history. The jugular veins being gradually compressed the blood returns from the brain with difficulty, hence fat people are sleepy & subject to the apoplexy.

Too much fat in the lungs occasions a difficult respiration. They are likewise subject to become dropsical who are too fat, & to such this disease more commonly proves fatal, perhaps by compressing the veins & thus preventing the refluent or extravasated lymph from being absorbed into the blood & carried out of the body by the proper emunctories. It also favors the generation of calculi.

1/2/ Quo plus pinguedinis animalia habent, eo minus ipsis est sanguinis. Histor: anim: l iij c 19

Of the arteries

The blood vessels in man and other animals furnished with a heart are divided into two clases. The one are more dence & solid & recieve the blood, as we shall hereafter shew, from the heart, & convey it to every part of the body. The other clase is like the former only thinner & softer recieving the vital liquor whether the blood itself or other humors which when united together constitute the blood from all the parts of the living body & conveying it to the heart.

The ancients called both these clases of vessels by the name of veins, thus Hippocrates used to call those vessels veins which pulsate & by that appellation he understood the pulsating branch of the carotid arteries in the temples. Aristotle reckoned but one kind of veins not two, & called the aorta itself the smaller vein. But the name of arteries afterwards arose from the similitude of the name to their supposed office of being vessels that carried air or a vital spirit, for as a pipe carries air into the lungs from that office it first got the name of artery which afterwards

Of the arteries

when the first class of blood vessels receaved the name of arteries they distinguished by the title of aspera or rough. The name of arteries was afterwards more accurately determined by Herophilus & Galen so that in the time of Aulus Gellius the physician who said that the veins pulsate caused a laugh for the more knowing then used the name of arteries. And now without disputs the names of artery & vein as the things themselves are separated.

All the arteries in the animal body are tubes the section of which is a circle: but I dont imagin that this figure of the section of arteries arises from the equable pressure of their contained fluid on every side tending to a perpendicular for that theorem only takes place in a tube whose form: ness is every where the same & which is forced by no extern: cause to give way more in one place & less in another so that its extentions may be taken for equal long perpendicular lines pressing on all sides, by which pressure as it were a curved line is formed which is called a circle. But if

any part of an artery happens to be more firm & gives more resistance to the blood or should be prefsed upon by other causes, or which in one part is surrounded by other parts of the body that easily give way & in another is confined by the immoveable vinus of a bone it is not in the least to be doubted but from the resistance being increased in the latter and diminished in the former place those lines will become unequal perpendiculars & make the artery of a different figure from that of a circle: and we know that the venous receptacles are certainly made up of triangular curve lines.

It is commonly received in the definition of arteries that they are conic that is, that a section of an artery is less than the trunk from whence it proceeded & that the capacity of any artery is larger the nearer the heart, hence they are called conic converging vessels: thus by tracing the aorta thro' a single branching to its smallest extremity as in the finger we certainly have a continued aorta forming a single canal the origin & base of which is in the

heart, but the end or vertex in the finger. But with regard to this definition of an artery so commonly received there are many things to be attended to in order to avoid error.

For first, this decrease of the arteries seems to depend less on the distance from the heart than on the magnitude of the branches which any artery we take for a trunk gives off; for as long as any artery runs on without giving off any branches it is found by measuring not to decrease examples of which are the umbilical artery the carotid & vertebral arteries, and according to Lenac the aorta while in the thorax, the humeral radial and internal maxillary arteries: hence we learn that an artery which we commonly call conical & convergent is rather a series of cylinders which are so adapted to each other that at every ramification it becomes smaller, like two cylinders the larger of which is above the ramification the smaller below it.

Further it is certain from the experiments of Haller & Hartin that all the arteries in the human body above

this

their division as often as they divaricate in branches are a little dilated. For while the two sides of an artery are continued into the two sides of two branches they diverge and at first the trunk is somewhat broader than the branches distinct from the trunk.

Lastly it is necessary that all the capillary arteries should be cylindrical as well from their frequent anastamoses as much returning to a trunk as it sent off, as, that the diameter of one globule of blood is equal to & fills up the whole capacity of the artery; and their cylindrical figure is easily seen by a microscope & are thus painted by Lewenhoec, Cowper & Cheseldon; the same may be seen in the larger arteries in the tails of fishes

Of the coats of the arteries

1st Cellular. adventitious. Therefore an artery is a tube made up of several membranaceous concentric cylinders or tunics as it were cemented together. The external is described by almost all anatomists tho' rightly by very few. For within the pericardium the external membrane of the heart

heart is continued on the aorta & surrounds it, between which & the proper tunic of the artery is cellular membrane containing fat & small vessels. The pericardium adheres to the aorta as it passes thro' it but does not give off any covering to it. In the thorax the left part of the pleural sac is incumbent on the anterior part of the aorta, & in the abdomen the peritoneum covers it & the iliac arteries almost in the same manner, & seems to afford an exterior smooth tunic to them, but it is not a true coat as the posterior part is entirely destitute of it being connected to the membranes of the vertebræ by cellular substance only. The same may be said of the dura mater with regard to the arteries within the cranium: but in the neck, extremities & other parts where there is no such membrane covering any adjacent parts no tunic can be found that can be called the exter: coat of the arteries, & here we entirely recede from the common doctrine of the schools which reckons an external tunic to the arteries as well as a muscular one. But this error has been fully refuted by Douglas, Monroo, Ludwig, & Haller.

But there is another very constant involucrum that that every where surrounds the whole artery viz. the tela cellulosa which binds these vessels to their adjacent viscera membranes peritoneum & muscles, & it is for the most part short & so much the more tender as the artery divides into smaller branches, but is never absent even in the small capillary arteries.

In the larger trunks of arteries this same cellular texture is more lax, made up of long fibres that are connected at very acute angles almost parallel & without fat, & in some places is called by the name of vagina by some authors as in the liver by Glisson, in the lungs by Lancisi & in the spleen by Ruysch. This coat is even where furnished with nerves & small blood vessels w.h are so mixed with each other as to give it a reddish appearance

Lancisi called this cellular & lax part of the arteries the villous coat. Boerhaave, Heister, & Nicholls call it the cellular. Willis and others the vasculous coat.

As for a glandular coat of the arteries which Vieussens, Verheyen, De Gorter & other writers mention, there is no such

thing unless we take little fatty glebes seen in this coat
for it.

2.d proper cellular. As this is the exterior cellular coat acording to some so they make an internal one, w.ch the nearer it arives to the muscular coat appears more firm being very dense elastic & furnished with numerous vessels being also of considerable thickness making the principal part of the arteries & besides which there is no other coat in animals having cold blood. This is the cartilaginous tunic of Vesalius, the tendinous of Heister & the ligamento-elastic of Senac, Nicholls, Cassebohm

But however firm this may appear & tho' dignified with the name of a true coat yet experiments demonstrate that its only a more compact & denser cellular texture, for if you endeavour to clean it, you will easily perceive it to rise in scales without end until you have come to the fleshy fibres, but you will find no smooth solid coat, if you macerate it in water the small intervals of the lamina will imbibe the water & gradually separate the fibres from

each other w.ch were before so very intricate & dissolve the artery so that it will appear like a mere sponge. Nieuwens first made the experiments which induced him to imagin that the whole artery is a mere spongy substance without muscular fibres. Douglas, Monro & Haller have also demonstrated it to be only cellular substance.

3.d Muscular. After this principal part of the artery there follow internal fleshy fibres which in the begining of the aorta, especially, are very copious and conspicuous & in which place are found many strata of them, some of which lie under others are dense hard & separated by very small portions of cellular substance; they are bent round into a circle, tho' indeed no fibre makes a compleat circle or can be compared to a ring, for as in all other muscles the strait & short fibres at their extremities are turned off longitudinally & hid under the adjacent fleshy fibres of the same kind. Some call them spiral from experiments made on oxen, but the industry of the accurate

Morgagni has shown it to be an error. Galen and the ancients rightly enough called them transverse. This is the muscular tunic of the arteries allowed by most anatomists & which Monro calls the first coat of an artery. In the smaller arteries the fibres appear gradually diminished & in the capillaries are not perceptible by the best glasses.

Many anatomists propose other fleshy fibres disposed longitudinally of the artery & in animals having cold blood this is sufficiently established, as in a Turtle by Merry & in a water frog by Charlton. Willis makes the interior stratum of fibres to go longitudinally in men & in that has been followed by other writers. Lastly other celebrated men judge the existance of these fibres sufficiently evident from the two ends of a cut artery receding from each other or becoming shorter: that phaenomenon is indeed true. & in every systole this artery becomes shorter returning again to its former length in its diastole.

But neither microscopes nor the industry of more

modern anatomists to whose authority we may better trust have ever demonstrated longitudinal fibres & here we must be careful not to take some plices of the internal membrane for them, nor is it safe to accomodate their fabric to phenomena for to the producing the effect other causes may lie hid different from those which first offer themselves to our senses and seem to favour our opinion.

4:th interior cellular. Between the muscular fibres of the artery & internal membrane another cellular tela is interspersed as between all dissimilar membranes. It is very short, thin, without fat & difficultly demonstrated, but for its existance we have the authority of Albinus, Walther & other celebrated men. And it is certain that between the muscular & internal tunics that juice is effunded which at first becomes callous & then bony & forms hard scales dispersed through the artery: hither we may refer the steatomous thickening of the internal coat which Monro saw to have obstructed the artery. vid: med: Essays.

3.th internal. The internal membrane of the arteries is smooth, uniform, thin & like the internal membrane of the heart of which it is a continuation; it is called by the ancients aranеosa by the moderns nervous. Some imagin there are pores in it but they are not manifest. It is for the most part soft nugous & connected to the muscular coat by a lax cellular texture in the arteries of the viscera. Monro compares it to the villous coat of the intestines. It is very smooth by the perpetual rapid motion of the blood & in a sound state is so dense as to prevent the exudation of it.

The internal surface of the arteries which is rubbed by the circulating blood is smooth in the human species & has nothing like valves in it.

The branches which proceed from the arteries go off mostly obliquely & always at acute angles. At each ramification two arches may be distinguished the one nearest to the heart is the most arched whether you respect the branch or the arterial trunck, this leads the blood coming from the heart as thro' a gutter into the ramifying tube. The other arch is semicircular.

Of the arteries

Vasa Vasorum. Every larger artery is furnished with smaller arteries, veins & nerves: this is a modern discovery for Pliny says no doubt from the schools of the ancients that the arteries are destitute of nerve & blood. Willis first described small arteries of arteries distributed thro' what he calls the vascular & glandular coats. Then Vieussens, but Ruysch described them more accurately & elegantly & according to his usual method gave cuts of them. since Boerhaave has treated of them very exactly.

The origin of these arteriola is various, in the vessels nighest to the heart many of them arise from the coronary arteries and unite so as to form a net-work chiefly on the external cellular coat but gradually sinks in among the other coats

The branches of these small arteries in a fetus & young subjects may be seen without any artifice or colored injection in the coats of the aorta & pulmonary artery making a conspicuous network; but in adults & old subjects they are less conspicuous unless filled with a colored liquor

By these arteriola the coats of the larger arteries are nourished & a vapor exhales from them which lubricates the cellular spaces as is manifest: But that they any way

assist in effecting the Systole of the artery as Boerhaave conjectures we shall in another place show to be improbable.

These arteries of arteries necessarily suppose corresponding veins which reconvey the blood from the arteries

Nervi. Many nerves go to the arteries especially the larger ones. thus soft pulpy branches arise from the great ganglion of the intercostal nerve which is in the upper part of the neck & are distributed to all the branches of the carotid arteries, to the lingual, maxillary, temporal, superior thyreoid, & occipital arteries

Seeing it is believed that there is no muscular fibre without a nerve since without that influence which proceeds from the nerves they contract very feebly; it is not to be doubted but there are nervous twigs sent to the muscular fibres of the arteries. tho' no one that I remember has demonstrated them.

If there are muscular fibres in arteries they must necessarily be of an irritable nature since irritability is inseparable from the muscles of the human body; nevertheless its necessary to treat more distinctly & minutely of the contractile nature of the

arteries lest we fall into an error.

And first the firmness of the artery alone which when cut by transverse sections preserves its light even in the arteries of a chick. A vein being cut collapses but an artery retracts itself & preserves its capacity which retraction seems to be a wise provision of nature to stop hemorrhages from divided arteries

Besides this contractile power of the arteries proceeding from the nerves, they are endowed with elasticity w: continues even after death, for the artery of a bullock being stretched with the fingers on letting it go it suddenly contracts itself or being distended with air between two ligatures or puncturing it the air is expelled with impetus.

There are other phenomena which demonstrate the contractile nature of the arteries, for the finger being thrust in a divided artery is strongly compressed; a ligature being made on the aorta & pricked above it the blood will be strongly ejected when the heart is at rest; two ligatures being made on an artery it will nevertheless empty itself between them which cannot be owing to the impulse of the heart as the

ligature is interposed between and the aorta being tyed the blood nevertheless passes out of the artery into the veins so as to leave it empty which also must be solely owing to the contractile power of the arteries as it succeeds when the heart is taken out to which add that in every systole of the heart the artery is dilated by a wave of blood forced into it, but upon the action of the heart ceasing they immediately contract to their former capacity.

The strength & density of the arteries depends on the thickness of the cellular fabric & the intimate union of the fibres of which that is composed. It was long since known that the strength of the aorta was very great, that the pulmonary artery was thin & that the arteries of the brain were very tender and brittle and it was generally recieved that the strength of the arteries was as their diameters, that the trunks were very strong & the branches so much the weaker as they were smaller.

Wintringham by his experiments found that the arteries were every where sufficiently strong & fit for sustaining the force of the heart & besides that their densities are in an

uncertain & variable ratio. That the aorta is proportionably the weakest, & that the proper cellular or tendinous coat, as it is sometimes called, between the external & internal coats, is the most brittle part. It appears likewise from these Experiments that their strength as well as that of the veins is in an inverse ratio of their hardness. Thus it appears furthermore from hence, that the firmness of the arteries is not diminished as their diameters are lessened, but is actually increased, & the trunks are found to be universally weaker than the branches. And secretory arteries are stronger than others. Besides the convex part of an artery we learn is somewhat stronger than the concave part, & the arteries of the feet are harder than the rest.

However these observations may appear at the first view to be repugnant to the received theory, yet when more nearly considered they are found to agree exactly with it. In the first place, the arteries of the limbs are in more danger of compression than those near the heart, as well from foreign weights & surrounding bodies as from the action of the muscles, therefore they are more firm as they ought to be. This provision of nature is very manifest

in the nerves, which are softest & almost of a gelatinous texture when they are firmly protected by bones as the intercostal trunk may serve for an example; but the nerves are sheathed with a compact cellular substance wherever they are liable to receive any injury as in passing through the muscles of the limbs. Besides it appears from the experiments of Winstringham, that the hard arteries easily broke, but the soft veins are less liable to that accident, & those vessels which suffer themselves to be stretched universally resist the force of the blood the best: nature has therefore framed those arteries softer & less dense which are near the heart & which receive the first & whole impetus of the blood, so that they are in less danger of suffering violence themselves & perhaps will be longer before they ossify; for the nearer the heart the greater is the danger of both these accidents. And even with this security as the greatest impetus of the blood is in the arch of the aorta so aneurisms happen there most frequently.

The observation of Lancisi is not however repugnant to the above, viz. that the strength of the arteries is not the

same in all men, & that thre are instances to be met with wherein the arteries are weaker at the origin than in other parts

Course & general distribution of the arteries

The whole of the human body is supplyed with arteries except a few membranes. They generally pass along the cellular membrane. They have never yet been observed in the arachnoid membrane of the brain & spinal marrow, in the cornea skin, in the membranes of the navel string, or in the hairs of the body except the roots of them. A vascular circle surrounds the border of the cartilaginous epiphyses, from which branches are seen to enter the cartilages of young animals. Dr Hunter has preparations by him of arteries running through the substance of the solid bone of the Tibia branching in their progress, as in softer parts. They are rendered visible by soaking the bone in æthereal spirit of turpentine.

The course of the arteries is different from that of the veins: for as the trunks of veins run just under the skin & the smaller branches are deeper, so the subcutaneous arteries are

are only short & small branches of longer trunks which run deep & through safer parts. The arteries & veins do not always accompany each other. In many places the veins forsake the arteries, the vertebral arteries pass through the bony channels of the transverse processes, but the veins pass along those processes less guarded. The arteries of the radius those of the cubit & tibia have but single veins & those not large enough to accompany them, except the external jugular vein & the large veins of the arm as the cephalic, basilic & each saphena pass under the skin accompanied by very small sprigs of arteries or without any arteries at all.

Nature by this contrivance seems to guard against the manifest & imminent danger of wounds in the arteries, seeing the blood is impelled into them by the immediate force of the heart itself, & which would be expelled from the wound with great danger; whereas the same blood returns by the veins having its velocity greatly diminished: wherefore wherever the course of the blood through the veins is safe being guarded by bones or large muscles there the venal trunks have

have arteries accompanying them. The particular fabric of the veins in the brain make an exception to the above.

The smaller branches of arteries & veins generally accompany each other; thus the veins of the Tibia which forsake the arteries of the part return to the same arteries in the toes. There is no cutaneous artery of any length — There are no proper veins that run deep, for although their trunks are placed a little distant from the arteries, yet the branches of each accompany each other as the vena portarum vine pair and branches of the coronary veins & arteries. The progress of the veins is more diversified, that of the arteries is more uniform.

Rami arteriarum. Having considered the trunks of arteries, we now proceed to a consideration of their branches. Keil has assigned very liberally a forty & fifty fold division of arteries & on this manifold divarication of them hath raised the superstructure of his theory, which supposes a very wonderful retardation of blood in the smallest vessels. But Haller has sometimes counted the division of branches beginning from the heart & proceeding to the small evanescent arteries in the coats of the intestines & scarcely ever found them to amount to twenty divisions.

Lumen ramorum. It is a matter more worthy our notice, that in the whole animal body, the capacity of the trunk is always less than the capacities of the two branches which proceed from that trunk, however frequent the division of the artery may be.

Different writers have endeavored to find out what is the ratio of the branches to the trunk. This is not yet accurately ascertained, but Haller imagins that the lights or sections of any two branches taken together always exceed the light of the trunk from whence they came, in nearly a sesquialteral proportion, or as one & a half to one or thereabouts. Be that as it will, it is plain that ramuing through the several divisions, till we come at length to the extreme capillary brambles the united capacity of them all must greatly exceed that of their trunks. As different authors have computed this proportion very differently, I pass over their various calculations for the present. It is sufficient to observe that however variable may be the ratio of the section of the trunk to the sections of the branches, the arterial system is an inverted cone whose apex is in the heart, & its base in the smallest arterial vessels of the whole body; so that the portion of the sum of all the branches to the

trunk must be great. For if we were to make an estimate, & to suppose there are just twenty divisions from the aorta to the smallest sized artery in the body, the ratio of all the branches to the aorta will be very near as the twentieth power of the number three to the twentieth power of the number two, which is a very equilateral proportion observed through all the divisions.

Anguli ramorum. The first law which we see observed in the division of an artery is, that in every division the larger branch is in the direction of the trunk, & that which is lesser goes off obliquely from the trunk; hence most angles under which the arteries divide in the human body are less than right angles i.e. are acute: some of them approach to right angles, others are semiacute & others persecute or very acute: there are instances enough of them all.

Those angles which are described as right angles & which seem to be so, are often less than right angles before the vessels have been too much cleansed from their cellular substance which served as a band & determined their angles.

Under the like circumstances, those which are commonly called obtuse angles, were in their very beginning acute angles

but so that in coming off from the trunk the branch formed at first an acute angle, but a little way on, it began to be reflected & to become retrograde, as may be seen in the umbilical, intercostal & epigastric arteries.

The large angles, whether obtuse or right angles, are those formed at the origin of the anterior spinal arteries & the inferior arteries of the cerebellum & the coronary arteries.

There is no certain determinate order of angles, according to which they come out from the aorta & its branches. Many celebrated men have given much into hypotheses when they have written that the smaller branches come out under greater angles & that larger branches come out under smaller angles, or when they have affirmed that the branches of smaller arteries nearer to the heart were obtuse, & gradually became more acute, till at length the extreme ends of them were very acute; for we see that the coronary arteries come out at very great angles, as well as the intercostal & lumbal arteries, but the seminal arteries come out under a small angle & the middle artery of the sacrum under a very small angle, but a little: wards the lateral arteries of the Sacrum form very large angles again.

Of the arteries

If we examin the angles of the smaller branches we shall find most of them to be acute, as in the larger arteries, & some of them very acute, some larger & some smaller which shews how ill grounded those general assertions have proved. But we have further to offer concerning the angles of arteries and the arterial network which is observed in many parts of the body which we leave till we come to treat of Secretion

Flexiones. In injecting the arterial vessels with tallow & the like substances we often find them assume a winding figure, even amongst such as we little suspected to find so, as the arteries of the limbs, of the radius, the ulna & those of the leg. By this means the moveable parts of the body admit of flexion & extention, & all the variety of motions which are natural to the parts without danger of being over-stretched or ruptured thereby.

The injection of the arteries seems to restore that state which they have in their diastole. Wherefore it seems credible that these arteries suffer alternate flexions in living animals. These same arteries when they are found empty, as they are in dead bodies become strait. They recover that straitness likewise

when the cellular threads which bind them to the neighboring parts are cut, so as to set them loose. Anatomists generally paint them strait as they find them cleared by dissection & not as they are when filled with blood in the natural state of the living body.

Some arteries affect a very particular meandring direction, such as pass through moving viscera or a membrane of a mutable magnitude; so that these arteries necessarily become at one time longer, at another time shorter according to the various changes those parts undergo in the different conditions & circumstances of life. Thus the coronary arteries of the lips, the arteries of the uterus, of the intestines, especially the larger ones, the arteries of the iris & of the navel string all affume that meandring direction. For sometimes the lips are shut close and appear of but a very small magnitude as in sucking & whistling, sometimes they are stretched to a great dimension in gaping or laughing. The arteries of the uterus are much extended & become straiter as pregnancy advances. The larger intestines are greatly distended with faces & by wind at other times they are narrowed into a very small compass

by their peristaltic motion. The pupil, becomes smaller or larger as more or fewer rays of light are suffered to enter it at a time. The naked string of a fœtus in utero must necessarily approach nearer to the placenta at one time, & be stretch'd longer from it at another in the various movements & situations of the child. In all these cases the arteries of those parts must sometimes be contracted into a shorter space & at other times be stretched into a greater length. The same is true concerning the arteries of the spleen, stomach, tongue & lungs

The design of nature in this oeconomy is very manifest. A winding artery is evidently longer than a strait line passing through the middle of those bendings in it & which would measure the length of the artery if it were strait. An artery therefore may become winding, when its extremity requires at any time to be removed further from its origin, & when it can be lengthned without any inconvenience whilst the turns or windings mutually recede from each other & the artery unfolds its whole length which being now stretched out measures the distance of the two extremities.

The nature of these flexions in the vessels is such that

the artery winds round an imagined line, so as to bend above & fall again below that line. A fulness of blood as well as anatomical injections increase these flexions. The arteries of the Brain which empty appear to be almost strait, but when filled they appear winding. And those arteries which appear winding when empty do on being filled suffer an incurvation into lesser angles, if in the mean while, that part of the animal body where they are placed does not change its length. Another cause of the flexions of arteries is their accomodating themselves to the intervals between bones as the internal maxillary artery.

Another kind of flexions is when large trunks of arteries are suddenly turned back on themselves in considerable circuits or bends, so that the same artery forms two or three very acute angles with itself; there are but few instances of this in the smaller arteries, but of the larger arteries we have in the carotides, which make a large turn under the skull in three or four different directions. The vertebral artery makes such another circuit partly under the atlas & partly in the sulcus or groove of the atlas. The

Of the arteries

The cellular web which is connected to the arteries frequently occasions such bendings of those vessels, which disappear however on removing that cellular substance.

Anastomoses. The anastomoses of arteries are the conjunction of arteries with each other, which happen from different trunks uniting into one trunk, or from an intermediate branch conjoining two trunks together.

These unions of arteries were but little known formerly, but now since anatomy has been greatly cultivated & the art of injecting become more frequent, this intercourse & communication of arteries with one another is well known.

There are two very large trunks which run into one, at an acute angle in the fœtus, as the trunk of the pulmonary artery produced & the aorta unite into one dorsal artery in man, but more especially in birds, in which the pulmonary artery is extended to a greater length before it is conjoined with the aorta.

It is more common for two trunks to unite indeed in such a manner as to meet in different directions, & the narrower extremity of one artery is so continued into the narrower part of the other that the streams of blood run counter, to each

other. Such a kind of communication is in the arch formed by the arteries of the superior mesenteric & its branches distributed upon the middle of the colon, with the ascending branch of the left mesocolic artery. But this is only an instance of many that might be given, for there are almost innumerable arches of this kind all along the course from the stomach to the rectum.

But there is another sort of anastamoses still more common when the small branch of a large trunk unites with a like small branch of another large trunk. This structure is so very common that there is no considerable artery in the human body which does not communicate with the neighbouring arteries by numerous sprigs of smaller arteries arising from this trunk & uniting with smaller sprigs of neighbouring trunks, so that it would be a difficult matter, to run over every instance which might be adduced of this sort of communication; a few examples may suffice. There is an arterial circle formed on the brain by the union or anastomoses of the single & common trunk of the vertebral arteries with the two carotids, by which the encephalon is

entirely preserved from dangerous obstructions; for as no less than four arteries conjoin to form that circle, the passage through three of them may be entirely obstructed yet the brain & cerebellum will be all over copiously supplyd with blood by the fourth. From the preceeding arterial circle perpendicular arteries on all sides arise which inosculating with each others lateral branches, form lesser arterial circles, from whence again spring other lesser perpendicular arterioles which again form still smaller circles & branches as before, even to the smallest which escape the sight.

The conjunction of the radial, the ulnar, and posterior interosseal arteries, with each other, & with the various smaller arteries which lie deep in the humerus is well known on account of the use of these anastomoses in the operations of Surgery

A similar anastomosis takes place between the anterior & posterior tibial arteries: & there are considerable conjunctions between the occipital & the vertebral arteries near the atlas.

The epigastric arteries inosculate with those of the uterus & hypogastric arteries: from this communication

we account for the great sympathy between the uterus & breasts of women; hence we see the reason why, after parturition, the blood which in time of gestation was determined to the uterus for the nutrition of the fœtus is now determined to the Breasts from whence milk is secreted for the nourishment of the child.

A kind of network is formed by means of the anastomoses of arteries in the muscles, uterus, lungs, &c: It is common for an arterial trunk to bifurcate & its branches to inosculate with the smaller offsets of the neighbouring arteries, so that in the periosteum pia mater, &c: there is no branch to which there is not a free communication between it & every other branch of the same membrane; the further account of which we defer till we treat of Secretion.

Sines. 1.st Vena. It now remains that we speak of the various terminations of arteries.

The first & most frequent is the termination of an artery in a Vein, so that veins are only a continuation, or rather the reflexion of an artery. This termination was almost wholly unknown to the ancient physicians, for they supposed a

kind of compacted blood to be interposed between the arteries and veins into which the arterial blood was effused, this substance they called parenchyma. Aretaeus supposed the substance of the liver to be made up of a congealed blood & that the kidneys were made up of a similar substance. Galen every where makes use of the word parenchyma when he speaks of the substance of the liver, lungs, kidneys, spleen, and other viscera. The ancients were not however wholly ignorant of the blood's passage from the arteries to the veins; so far the disciples or physicians of the school of Erasistratus attained as to know that as often as Galen had objected to them the blood's pouring out in such a gush from the extremity of a divided artery; for Galen by no means was ignorant of, or denyed the communication of vessels, nay he explained an inflammation as if it arose from the blood's escaping into the arteries from the veins; but he did not know the true course or circulation of the blood. Many things were spoken conjecturally by Severinus & others concerning the connection of the arteries & veins but Malpighi was

the first who confirmed it as it was seen by the help of the microscope in the bladder of a frog. After him Edward King upon the authority of his own experiments said that the fleshy parts of the viscera was composed of new vascules in place of parenchymatous substance. But Ruysch experimentally refuted the opinion of an effusion of blood being placed round the extremities of the arteries as in a sponge whereby it appears that the escape of fat into the cellular substance would only produce a confused mass such as he never found after a successful injection. He afterwards observed that fat cannot pass in a continued thread from the arteries into the veins if there were any spongy space interposed into which it would be diffused. But still the existence of parenchyma or effused blood into a spongy cellular substance was not given up, many still contended for it. In the mean time Lewenhoec published his letters; after which there seemed to be no room for doubt, he was indeed an illiterate man, but exceedingly well skilled in the use of

the glass lens, but he was the more likely to persuade us of the truth of his observations as he was less given to hypothesis

By the use of glasses he manifestly discovered in fishes & other aquatic animals covered with a pellucid skin that the arteries were continuous with the veins. He observed that in the tails of fishes more especially, the artery was incurved & so passed into a vein which returned towards the heart in a contrary direction; that some of these little arteries were capable of containing a single globule of blood others, two or three and so on.

Another mode in which the arteries are conjoined with veins is of this sort, the artery runs almost parallel with the vein; in the tails of fishes the course of the vessels is described by the situation of the small bones; small branches come out from the artery of the breadth of one or two globules these being inserted into the vein bring back the globules of blood towards the heart, or a number of little arteries flow together into one vein. As the art of filling the vascular

system with suitable matters of injection came to be known
experiments were made to establish the continuity of the
arteries with the veins & accordingly at one time or another
the venal system in all parts of the body has been injected
by matter forced into them through the arteries, especially
the viscera, as the lungs, liver, mesentery & kidneys. I
myself have seen injections of the emulgent veins by means
of injecting the arteries. A column of water 10 feet high
so filled the body of an entire ox that the water forced
its way through the arteries into the veins.

One objection which has been offered to this doctrine
is, that some who have tried were not able to make any
liquor injected into the veins pass into the arteries. But
other experiments may be opposed to them; thus Drew
having poured quicksilver into the thoracic duct filled
the veins of the brain in that manner, from whence the
arteries of the pia mater were likewise filled.

By injecting the vena portarum & making the
injection

injection pass on towards the guts, the meseenteric arteries have also been filled with the same wax. Most commonly injections of the veins do not succeed so well as the arteries: for the same force cannot be safely employed; for if you should insert a tube into the large trunk as you do in those of the arteries, the valves would resist, but if you insert the pipe of a syringe into a small vein you dare not use much force.

Another objection is taken from a liquor flowing into the cellular membrane. This is only true of watery or thin liquors, such as Ichthyocolla dissolved in spirit or warm hogslard, or when fat is forced along with such impetus as to rupture the vessels; but this accident may be avoided by adding a little wax or cold oil, & not using too much force; for then what is injected into the arteries will return by the veins. The former event only shews that there is a ready passage from the artery into the cellular membrane. We may add to this that in such animals whose vessels may be seen by the naked eye, & in which we behold a manifest continuity of the arteries & veins, it appears that there is no spongy, cellular substance

or any thing like an opake medium interposed between, or any way surrounds them. Hence the notion of a parenchyma interposed between the conveying & returning vessels is justly rejected by men of the greatest authority.

It is well known however that after the most successful injection, there is a great quantity of flesh remaining which receives no colored liquor, whether it be cellular substance which remains white, or vessels of a smaller kind into which no thick matter is capable of penetrating. But these small vascula into which the blood passes from the arteries into the veins, are tender, very pellucid, & scarcely visible to the naked eye, & not easily discerned by the help of a microscope. In an incubated egg passages seem to be made through the yellowish pulp as if they had been drawn by the point of a needle next day the membranes are seen very plainly.

2d. Ductus Excretorius. A second termination of arteries is into excretory ducts: that is, into canals very like to a vein uniting in their passage with other like canals into larger trunks which are constantly increased with new roots like the former. There is a twofold diversity between ducts of this kind & veins;

for they contain a liquor different from blood, & they do not return it again to the blood, but convey it into some larger cavity or quite out of the body, as the ducts of the lacrymal gland.

That these kind of effects are contended from the arteries is scarcely to be confirmed by the testimony of our senses. Lewenhoeck by the assistance of microscopes never discovered the root of an excretory duct arising from an artery, but observed numberless small veins arising from them. It follows therefore that the diameters of the beginning excretory ducts are smaller than the diameters of the beginning veins; perhaps their transparent tenuity may contribute somewhat to conceal their little roots.

In many places it is not easy to push any fluid thro' the arteries into the excretory ducts, sometimes however the fluid injected by the arteries passes out in an uninterrupted canal through the excretory duct. It is very easy to make an injection to pass through the arteries of the kidneys into the ureter: & it is necessary indeed to tye up the ureter if we wish to fill the vessels of the kidney throughout with any proper injection. Haller & others have succeeded in injecting the oil of

turpentine colored through the hepatic artery or the vena portarum so as to pass into the biliary ducts.

But nature herself has supplied other experiments that are no less conclusive. It frequently happens that blood repelled from the uterus, or abounding in too great quantity, or moved with too great violence, flows through those excretory ducts. This is a confirmation of their being continued from arteries, especially as it is not at all probable in most of those instances that the vessels are ruptured during that a confirmed state of health & the usual secretion of the natural liquor succeeds again in a little time after.

A periodical discharge of blood by urine & other unusual passages has sometimes happened. A flow of blood by the kidneys & urine has happened in place of the menstrual discharge.

Blood has flown from the breast in place of milk, as well as through other parts of the body, as the eyes, & even in the legs, as I once knew a case compiled. Vo: med: Ge:

In Hebwings observations we read of a girl in whom the menses discharged themselves through the eyes by drops

from the seventh year of her age to the thirteenth & then passed off by its more natural course; menstual blood has flowed also from the salivary ducts.

There are many instances to be met with of more extraordinary fluxes of blood not natural to the body. Pisa in his natural history of the indies, tells us of blood flowing out of the ears, nose & eyes after the bite of a particular sort of snake. In the worst sort of yellow fevers hemorrhages happen from the eyes nose & ears, as well as other parts of the body with a fatal event. After a dose of poison blood has issued from the Kidneys, the passages of the tears & way. In the philosophical transactions N°203 we are told that an icteric patient, the blood issued out of the lacrymal gland to the quantity of two pounds with a like fatal event. In the worst kinds of small pox the blood has flowed out by urine which is generally a fatal symptom

These examples tend to prove what is contended for; although they are not natural to a healthy state of the body, yet they do not argue a rupture of the vessels or new passages, but only a dissolution of the blood. For we undertook to shew

that the excretory ducts had their origin from the vanquineous arteries. The morbid laxity of the vessels or the tenuity of the blood does not weaken that demonstration.

To which we may add, though we allow it to be a rare case, that there is an instance related in Bertons memoirs of the academy 1744 in which the continuation of the excretory duct with the red artery could be almost demonstrated to the eye.

If then liquors injected from a red artery pass into various excretory ducts without delay, & if red blood from very slight causes such as do not change the solid parts escape into those ducts; if the testimony of the eye too is added to the rest, it appears plainly that the vanquineous arteries are continuous with the excretory ducts & that this exit may very safely, without the least fear of error, be considered as one of the terminations of those arteries.

3 Exhalatio. A third termination is that whereby a vanquineous artery either pours out its blood as it were from its rejected end, or a thinner fluid exudes through its pores, is effused into the cellular substance, or terminates

in a small exhalent vessel which is neither a vein returning to the heart, nor an excretory duct which is about to unite in the manner of veins with others like itself so as to form a large trunk, but it is quite simple & short & pours out its fluid from its open end.

From a diversity observed in them, there are several classes of these exhaling vessels established, for either this vessel opens into some cavity of the body, as the mouth, stomach, gut, nose, bladder of urine or gall-bladder, uterus, vagina, cavities of the ventricles of the brain, of the pleurae, pericardium, peritoneum, or of the tunica vaginalis; or this exhalation happens on the external surface of the body thro the skin, or into very small cavities of what are called crypte or else of true glands. The blood itself is sometimes effused from a red artery into the spongy fabric of the corpora cavernosa of the nipples, penis, & clitoris

When we treated of the cellular substance we then gave a remarkable instance of that kind of exhalation in which a liquor transudes from a red artery either through

pores or by very short canals which is in the small cavities of the cellular substance.

We have another signal instance in the lungs as is evident from the following experiment; If a pipe be inserted into the vena cava near the heart, & water colored blue be forced through the pipe, it will pass through the right side of the heart into the pulmonary artery & all the substance of the lungs which is of a vesicular or spongy nature will be filled with a bluish exudation which will pass frothy & mixed with air through the aspera arteria.

The blood itself imitates that exudation of the lungs in a very dreadful disease, for the lungs being impervious it is excludes a passage, & being impacted by the great force of the right ventricle of the heart pressing it into the obstructed arteries, it sweats out on all sides, & being effused in a liver like mass through the whole lungs it produces a most fatal kind of peripneumony; sometimes an obstruction of this sort is formed by menstrual blood which being prevented from flowing through the uterus is easily thrown upon the

air

air spaces of the lungs, & is discharged by Hemoptoe which is however less dangerous from this cause than when it happens to men from other causes; for the recovery of health which soon follows proves that the passages were only dilated but not ruptured.

An exhalation into the larger cavities of the body is demonstrated in the same manner; & the rise of it from red arteries is shewn to be the same with the exudation into the cellular membrane. All the membranes in the human body do likewise sweat out a vapor through invisible small pores which is often seen arising like a fine smoak from all the warm surface of the dura & pia mater of the brain, the membrane of the pleura & peritoneum where they every where cover the thoracic & abdominal viscera. This vapor has a fatid smell which resembles a volatile animal nature united with a dissolved oil. It may be called essential vapor of an animal as it contains the particular smell which different animals give out.

We find this vapor collected under the appearance of water in the cavities of the brain, thorax & abdomen after death, which

from its coagulating by fire or alcohal may be called coagulable lymph; It is by the assistance of this penetrating liquor that Anchyloses & other obstinate diseases are sometimes cured by thrusting the obstructed part among the viscera of an animal opened alive, or immediately after death, as the discharge of that vapor does not immediately cease.

We can easily imitate the generation of it by injecting either warm water or ichthyocolla dissolved in spirit. or oil of turpentine, or warm hogslard into the aorta of a man or other animal, or into the meventery or coeliac artery of the same, for similar drops then exude from the same membranes & fill the receptacles without any part being injured; thus too oil of turpentine coloured with red lead being injected into these arteries, the red lead will remain in the very small vascules whilst the oil of turpentine exudes, but which would be followed by the minium if the vessels were ruptured. Sometimes a part of the blood or something from it gets into these passages with the aqueous humors; it is no uncommon thing upon opening of dead bodies to find a red water in the pericardium, or in the cavity of the abdomen. we constantly find an aqueous fluid there in a fetus & oftentimes of a bloody color. Bleedings at the nose are of that kind: the

blood does not burst the exhaling vessels of the nose, it only dilates them. The gelatina of the blood passes out this way on the surface of the pleura, in many diseases of the breast, & by thickening often cements the lungs to it; this vapor it is which in a healthy state preserves the membranes & viscera contained within them free from concretion.

The easy passage of fluids, & the exhalation of the blood itself, demonstrates that the vascula through which this vapor passes are short, & arise likewise from the small vived arteries.

This exhalation has some analogy with perspiration, but it often proceeds from villi that are more evident, & transudes upon the internal surface of all the cavities of the human body, as the mouth, fauces, oesophagus, wind pipe, stomach, intestines, urine & gall bladder, renal capsula & uterus.

Any fine liquor injected into them readily passes from the arteries into those cavities. Blood often finds an exit the same way, without the least injury done to the parts, nay to the great relief of the patient, whether this effect is produced by a fever, retention of the menses, a plethora, or any other cause it does not make new orifices, but only dilates the native ones. Town in his treatise on the diseases of Barbadoes tells us, in the hoter

Islandes of the west-indies, where the body is greatly relaxed, that instead of the usual discharge of menses, blood frequently comes away by stool. many examples of the like kind may be met with in the commentaries to Boerhaave's Lectures vol: 5.

The menses have been sometimes discharged by vomiting without any great disadvantage. we have already taken notice of a periodical hemorrhage by the anus & by urine.

In the case of a patient mentioned by Valisneus, blood flowed out through all the little excretory passages of the body, as the gums, eyes nose & ears, by urine & stool, & yet the patient recovered. Albert gives us an account of a young man who labored under a chronic disease in whom the blood burst out by turns through the kidneys, lungs, stomach & intestines.

Marcellus Donatus in his rare medical histories tells of persons whose spleens were affected, from whom blood has discharged by stool & vomiting to the quantity of ten pounds, which procured relief & even a perfect recovery of the sick. An obstinate head ach has been critically cured by a discharge of five pounds of blood by stool. A salutary discharge of blood the same way has happened to persons in a jaundice.

Spindler in his 47th observation relates that such a discharge of florid blood amounting to twelve or fourteen pounds in twenty four hours once happened to the great benefit of the patient. A bloody Diarhoea has often proved salutary without any rupture of vessels, and the monthly purgations of women afford a constant example of the blood transuding thro' vessels destined at other times to an exhalation of a subtler fluid.

But lastly, waxy injections thrown into the arteries have been seen by many great men sticking into the ultimate villi, & Haller relates that he himself has seen the same, whence he concludes it to be very manifest, that small branches of arteries are produced into those villi, & terminate with a patulent orifice.

Cuticular exhalation. There is another kind of exhalation which arises from the whole external surface of the body, & from the superficies of the cutis or true skin, which is covered with the epidermis. This has been long known not only by the name of sweat, but likewise by that of insensible perspiration

This is likewise an arterial exhalation, & proceeds from

vessels continued from the cutaneous arteries. This sweat may be easily imitated by water injected into the arteries of the limbs, & into the aorta, especially of young tender boys, for it distills every where from the surface of the skin and is collected in blebbers by raising up the impervious scarf skin by which it is confined in the dead body; dissolved Isinglass colored, will pass the same way. It is less common to force watry injections through these small vessels as having not so great laxity as the internal villi, but this event happens sometimes, and blood itself sometimes finds a way into the vessels. Aristotle in his 3d. book & 5th. chapter concerning the parts of animals mentions some instances of a bloody sweat; in this he is followed by a number of writers

Doct.r Bayard has at this time* under his care a child that has red or bloody spots like flea bites all over its body, limbs, & face, which no doubt is either the blood itself, or the perspirable matter tinged with blood, which has passed thought those pores by which the matter of perspiration commonly passes, but this kind of fluid was too thick to pass off by the compact cuticle. It may perhaps be absorbed again by the inhaling vessels in the same manner as blood extravasated under the skin, by a blow or rupture of the vessels, is again taken into the course of the circulation. Sulpius likewise mentions a bloody sweat through the foramina of the skin. Huxham in his treatise of fevers makes mention of a diapedesis or percolation in form of a bloody sweat in acute fevers so as to tinge the shirt under the arm pits. Willeains in the yellow fever of Jamaica tells us of a slutary hemorhages bursting from the pores of the skin and which could be withstained with great difficulty

In the second part of the 5.th volume of Pechinei

* February 1760.

observations page 87 we have various examples of the
nerves passing through the hairy scalp & other strange
parts of the body, as the root of the finger nails, & other
cutaneous parts: sometimes the blood is impelled in a
particular manner through some pores of the skin. A
certain youth at stated times sweat blood from the extre-
mities of his little fingers which proved a necessary crisis,
as he became worse when this failed. We read of blood flowing
from the ears, ends of the fingers & toes, the tip of the tongue,
from the navel & angle of the eye; a daily sweating of blood
in a sound man for some time, if we may credit Benenger,
the bleeding piles injudiciously stopt have been supplied by
blood flowing thro' insensible pores, & in a magistrate of Leyden
from the end of his finger if I rightly recollect the account in
Boerhaave.

We pass over the bloody sweats in the scurvy which
may happen from a rupture of vessels, although the passages
are not visible. But the preceding histories, which are collected
from different authors, may serve to prove that the exhaling
vessels of the skin arise from red arteries.

Glandular exhalation. The last kind of exhalation is that which happens into glandi & cryptæ. We shall speak of this more fully when we come to treat of secretion. There is a manifest transudation into these glands from the red arteries just as there is into the large cavities of the body. This is imitated by injections whereby water, & sometimes wax is forced into their little caverns.

As in the former kinds of perspiration so here, ~~from~~ irritation or any other increased cause, sometimes pours out a coagulable lymph, & sometimes even forces blood through the watry passages. This appears in the sinuses of the urethra after the use of acrid injections.

4 In smaller vessels.

Lymphatics. This last kind of termination of a red artery into a vessel of a lesser genus carrying a fluid not red, has been, & is still subject perhaps to controversy.

These vessels differ from a red vein in the fluid they carry; & from an excretory in not conveying that fluid into any patulent receptacle.

Lymphatic vessels are filled by pushing a fine injection very strongly through the arterial system. In this manner Caspar Bartholine filled the lymphatic vessels of the Spleen & Kidneys from the red arteries. Borrichius by inflating the coeliac artery made the thoracic duct to turnify; the same event happened to Anthony Nuck in the Lungs, kidneys, spleen, & various parts of the human body, who is the principal author in giving an account of these vessels; the same success had Cowper in the liver & Walther in the kidney. water passes from the mamillary artery into the lymphatic vessels.

Some authors (as Mangetus in his Theatrum Anatomicum vol: 2 p: 204) have wrote that the lymphatic vessels manifestly arose from the arteries of the part. The vena portarum has a good deal of the nature of an artery. Loquetis tells us that the lymphatic vessels of the liver may be filled through the same & not thro' the vena cava as appears from his trials and those of other celebrated men.

From these observations Haller & other anatomists have concluded that the lymphatic vessels do actually rise from red

arteries. whether immediately from small capillary arteries
or mediately by the intervention of any kind of tube. but Doctr
Hunter the illustrious teacher of anatomy at London & D. Monro
the present able professor of anatomy at Edinburgh do contend
that the lymphatic vessels are a system of absorbent veins w:ch
do not arise from any kind of artery or other vessel. They alledge
that the origin of these vessels are 1:st from the cellular mem:
brane throughout the body. 2:dly from any cavity as the intestines;
It is universally allowed that as the course of the lymph and
chyle is the same, viz:t towards the thoracic duct, & some of
the larger veins in their course to the heart. so the lacteal &
lymphatic vessels are one & the same kind in their structure,
& office: Lastly the third origin of these which they allow is
that of the inhaling vessels on the surface of the body which
take up moisture from the surrounding atmosphere, or by
unguents & liniments of various kinds being rubbed on the
their vain admittance into the blood: The office of those inhaling
vessels is directly the contrary of the exhaling or perspiratory

vessels, & the same with the inhaling vessels which arise from the cavities of the body & the glands, & which often take up that water which has been deposited there by exhaling arteries of those we mentioned as examples of the second manner in which arteries terminate.

To prove the existence of these bibulous veins of the skin more fully, & to shew what a quantity of fluid may be taken into the blood that way, we need only to attend to that extraordinary case of a dropsical woman related to Boerhaave by a wise physician who attended the health of the Prince de Montecuculi at Vienna. This dropsical woman who tho' she took little or no drink had nevertheless a daily increase of the water & discharged large quantities by urine. As the reason of this appearance was obscure, the Emperor ordered watchers to set by the woman, that there might be no fraud in the case by giving the woman any drink privately, & it appeared that there was no deceit in the case. If we admit of absorbing veins arising by open orifices from the surface of the body there is nothing very surprising in this event.

for we daily may easily conceive more moisture to have been absorbed from the air by the veins than was discharged by the arteries; hence we have a reason why we become thirsty in dry weather & require little drink when the air is moist. viz: though we equally perspire yet in a dry air less moisture is absorbed, whereas in a moist air there is a much larger quantity of moisture taken in. But to return from whence we have digressed. Although numerous experiments are related which shew that milk, quicksilver & oil of Turpentine have passed from the mesenteric arteries into these veins as may be seen in Bidlow's Anatomy by Cowper, Tyson's anatomy of a pigmy, Ruhely on the spleen, Copel concerning the fabric of glands; I say notwithstanding these and other experiments Hunter & Monro are still of opinion that the lymphatic vessels are never filled from the arteries without a rupture of the artery & an effusion of the injected liquor into the cellular membrane from whence it may then easily find a passage into the lymphatic vessels which open every

where by patent orifices in the cellular substance: At least they affirm they never could succeed in injecting the lymphatics without such a rupture. from whence they deny that the lymphatic veins do arise from any kind of artery & endeavour to support their opinion by a number of curious experiments as may be seen in their treatices on the subject.

But Haller observes that he often injected the lymphatic vessels by fixing a pipe & sepinge to the trunk of an artery of any of the viscera. as the mesenteric arteries or to the trunk of the vena portarum, and in these experiments he could not say that the injected fluid had ever passed first into the cavities of the cellular web, before it found its way into the lymphatic vessels. He beheld, as he tells us, oil of Turpentine colored red enter into the lymphatic vessels preserving its color, whilst he could not find the least of his colored injection or any stain of it in the cellular substance. He cannot therefore agree with those writers who by their experiments have denyed that the lymphatic vessels can be

filled from the arteries, or that those vessels are not lymphatics in the lungs & spleen which have been filled in that manner. He observes it is no wonder that the lymph has often a reddish cast, or that some blood should occasionally pass into the lymphatic vessels & into the thoracic duct as he had often seen. Ruch likewise often found the lymph bloody. Langley also reports that the lymph appears red frequently in the lymphatic vessels of men who have been strangled, other authors have seen the same thing

Wherefore if any liquor injected from the arteries passes into the lymphatic vessels, & if the lymph ~~is~~ at any time is like blood, & also if any arterial blood is ever mixed with the lymph. Haller is of opinion that it cannot be ascribed to an error loci, but to a continuation of the lymphatic vessels from arteries, & that & that this kind of termination of arteries deserves a place with the other kinds of which we have already treated.

For my part I make no doubt but that there is a set of vessels which arise from the cellular substance & have their

begining or origin there), which take up lymph or any extravasated fluid in the cellular substance. At the same time I cannot doubt of the accuracy of Haller's experiments and his relation of them, so that an injection will pass from the arteries into the lymphatic veins without a rupture tho' not so readily.

Arteries not red. This is a different subject from the above. Passing over the opinion of Aristotle, & those obscure fibres containing a various fluid which he tells us, in his xiith chapter of the 3d book of his history of animals, are placed intermediately between arteries & veins; the famous invention of Boerhaave is, that there are cylindric arteries of a less magnitude than the diameter of a red globule of blood & therefore carry a finer fluid than that of blood.

In this invention the celebrated Boerhaave united the microscopic experiments of Lewenhoec whereby globules of various sizes are shewn to be in the blood, with the vascular injections of Ruysch in which it is plain that colourless vessels, and such as escape the sight before injection living

being filled with a colored liquor become visible to the naked eye. Thus the subtile genius of Boerhaave discovered that from the red arteries arose other smaller arteries carrying a liquor finer than red blood which small vessels were likewise conical & ramified, & that through these small arteries the said liquor conveyed to parts more distant from the heart. Evident examples of this structure were observed by this great man in the arteries of the tunica conjunctiva of the eye, for the arteries are pellucid & invisible in a healthy person, but they are seen ramified & conical as often as the red blood is forced into them by inflammation. There are few red vessels observed in a sound eye, but in the same eye when inflamed these red vessels become very numerous.[x] These small arteriola are evidently continued from the red arteries, seeing that both red blood enters into them in an inflammation & injection forced into the red arteries bring these likewise to view by filling them especially in a young subject.

But this kind of small arteries may be shewn without any disease or any help of art; for in the same eye the

[x] See Vansweiten's commentaries vol i p: 648

ciliary arteries are turgid with red blood, but the same blood seems to change color in those who have chesnut coloured, brown or bay eyes, as the small branches of these little arteries lose along the choroid coat or membrane of the eye: then it is certain that from the circle which runs round the uvea which is made up of these little divaricating arteries, other very small arteries arise, which in the manner of spokes from a wheel are carried in a serpentine direction towards the pupil between the two lamina of the Iris. These vascules have all the properties of arteries, they have branches, anastomoses & a conic figure, as well as veins to accompany them, but they only carry their liquid, unless any artifice is used to force in some other. It is an easy matter to fill them with colored oil of Turpentine.

But these small arteries are not found here only, they are extended to other parts of the body, but they are not demonstrated every where by such manifest experiments.

Lewenhoeck[x] on the faith of his microscopical & other observations tells us that there is not the smallest part in the human body, in which small vessels may not in like

[x] Arcana naturæ detecta p: 16.

manner be rendered conspicuous by inflammation, or an artificial injection of a colord fluid, which vessels before escapd the sight; & which now they are filled with colored tallow shew themselves to be possessed of all the properties of arteries. The intestines, the membranes of the brain & all the covering of the animal body appear as if painted with innumerable small vascula when they are filled by a successful injection; nor are these experiments difficult to make, for these small arteries are easily filled with oil of turpentine colored with red lead. But diseases likewise make the same small vessels conspicuous in the whole of a human body. No person ever pretends to have seen a red globule in the membrana corned of the eye whilst in a sound state, but inflammation brings reddish vessels to view. The skin, the membranes of the thorax & abdomen on being inflamed, & the brain itself in the plague is painted, as it were with red vessels, which are not visible in a healthy man; even the hearts of men that have died of a malignant fever appear very red.

Therefore as there are fluids in the body finer than red blood, so nature hath provided vessels fit for those fluids. both

arteries continued from red ones, & from ſpigs of the smallest
sized red artery as from their aorta to carry those fluids
to their destined places, & little veins likewise which carry
back whatever useful remains of it from those capillary
arteries into the common mass of blood.

Error loci. From the above account, the doctrine
of obstructions formed in the smaller vessels from an error
loci as Boerhaave terms it may be easily understood.

He called the passage of blood into vessels smaller
than what naturally contain red blood an error loci, for
these vascules of a conic shape may admit a globule into
the orifice of their larger extremity, but may resist it as it
goes further on, & that so much the more as the globule
passes further on into the small vessel continually growing
less in its course; for, the further from their origin which
is in the red artery, so much less must the capacity of the
smaller vessels be; hence a greater force must constantly
be exerted on the sides of the vessels & a greater resistance
opposed to the globule which is to dilate it; in the mean
time the force of the heart à tergo must drive on the blood

and propel the impacted globule into the narrower parts of the conical small vessel: Therefore unless the globule should be drove back again, or broke down into smaller molecula, the small vessels must necessarily at length be ruptured by the impulse of those globules, since they find admittance into them, but have no passage out again; or there must remain an obstruction. But the yellowish globules & such as before were not conspicuous now become red, from whence proceeds an inflammatory redness. It may also happen that the smaller vessels being relaxed whilst the powers of the circulation are low, may receive blood into them without any increase of the impetus: This theory may be compared with that of Erasistratus who supposed the cause of inflammation to be in the particles of blood which being impacted into the ends of the vessels destined for the animal spirits could not get out again.

But the genius of Boerhaave which was ever fertile in invention did not rest here; but proceeding on the observations of Lewenhoeck who asserted that a globule

of red blood was made up of six lesser globules into which it might be divided, & that each of these were composid of six others still smaller & so on indefinitely; he therefore supposed there must be a set of vessels smaller than red arteries accomodated to the size of this second order of globules, & arising from the red arteries. that these carried a yellow fluid in them, & again, that a still smaller order of vessels arising from the second & accomodated to the third sized globules were equally necessary & that these globules composed a fluid more subtle than the yellow humor. He proceeded further in this chain of reasoning & supposed globules still more minute & composing a more subtle fluid than the preceeding, which he could by no means imagine corresponded to the exceeding fineness of the ultimate vascules of the brain; thus he was for constituting other orders of vessels continually diminishing in size, as a third, fourth, fifth, &c: each containing finer fluids than the preceding orders, & allowed no end being found to this progression, or that the smallest kind of vessels were known.

Of the arteries

This doctrine supposes new errors of place and inflammations without any redness whenever the yellow or serous humor becomes impacted in pellucid vessels; such is the yellow erysipelas & the yellow lines in the Tongue which ausfabad omen. Haller mentions an instance which he saw in a woman who labored under a dysentery whose whole tongue was of a saffron colour. Examples are to be met with in authors of the menses being of a saffron colour.

Animadversiones. Let us examine how far this theory is firmly supported.

No body has yet refused that there are vessels smaller than the red ones; there are more instances of this than one in the fabric of the eyes, for the small pellucid vessels of the iris are well known as well as those colorless vessels which are by no means obscure in sheep & which pass from the retina to the vitreous humor; and lastly we may mention the small vessels of the crystalline lens whatever may be the origin of them. It is not probable

that red globules even singly & by themselves enter into these very fine pellucid organs the usefulness whereof wholly consists in their transparent purity. Nor does it seem impossible that the fine vessels of the cortical substance of the brain which secrete a nervous liquor, ever receive into them the red globules of blood, since it does not appear reasonable to suppose that the most subtle of all humors should be suddenly generated from so thick a kind of humor; but the most penetrating injection that does easily pass into the veins & fills the sinuses of the brain & so easily overcomes the narrow parts of the smaller arteries which are capacious enough to admit a single globule, yet fills but the smallest part of the cortical substance of the brain, so that what remains is composed of smaller vessels than those are in which the red blood circulates. That what remains not filled is not a confused mass but in like manner vascular is shewn from hence, that when the arteries of the brain are indifferently well injected, the smallest portion of the cortical substance of the brain admits

admits the red blood, but so many more colored vessels arise in proportion as the injection penetrates deeper. From this experiment it is plain that there are always smaller and smaller vessels in the cortex of the brain, of which only the large & coarser ones are filled by a slight injection, but it requires the utmost skill to fill the very small vessels, together with the use of a most subtle fluid as the matter of injection. We might here mention the small white vascular substance of Ferein of which he shews the viscera are composed and which are never filled with any colored liquor. From all these arguments united we may readily believe, that there are smaller vessels that arise from red arteries, & that they are transparent, & not visible by the assistance of any glass, but being impervious to blood globules they carry a thinner fluid. And thus we may reckon these small vessels amongst the terminations of a red artery.

What has been advanced concerning the error loci is not so certain; for it appears that a principal argument which

is brought in support of it is destitute of true strength. For whatever those vessels which were pellucid & escaped the sight are rendered visible & appear red from the blood or from any colored liquor injected into them; this change is not owing to their having been impervious before to red globules or those of a different kind from red. Henry Power in his microscopical observations p 59 observed long ago that the very small vessels were pellucid even though they carryed blood & that very justly seeing the blood globules are mostly pale when they go on solitarily & without others to accompany. Senac has used the same argument: the vessels of the eye or of other membranes which seem to be produced all at once by inflammation or anatomical injections have been looked upon by the above men as well as the celebrated Bellini & Duernay as small arteries previous to one series of globules & that from hence they are pellucid & not conspicuous.

Haller says he constantly finds such kind of small arteries & small veins in a living animal which escape the simple sight as in the area of the mesentery which appears naked & without vessels, but by the use of a microscope he can observe small canals

of the diameter of a single globule.

Certainly many, and perhaps all inflammations are not of that kind in which the blood sticks impacted in entire vessels. If we attentively look at the redness of an inflam'd finger or of an inflamed membrane, the part is not painted with vessels in such a manner as to leave intermediate colorless spaces as happens in the eye; the whole inflamed finger is red, the whole circle about the eyelids is also red, so is the circle about the pustules of the small pox; what are called inflammations of the stomach manifestly happens from blood effused into the interior cellular membrane; add to this the different events of inflammations, the resorption of effus'd blood, the generation of pus in the cellular membrane, or gangrene, which likewise happens from blood effused into the cellulous spaces, or rather thus whose juice is not compacted in vessels but in all the little cellular spaces of the indurated part. It is probable then that inflammations, most of them for certain, do not happen from blood impacted in the small vessels, but from the same exuding into the circumjacent cellular web. This is the most ancient theory of inflammation proposed by Galen & with a

little change of his words referred by Vanswieten to error loci.

Heller thinks that inflammation does not arise from obstruction; for an obstruction agrees nearly with a ligature which intercepts the free passage of a fluid through our vessels, but he will not allow that a ligature or an obstruction produces an inflammation. A ligature tyed about the largest arteries, as the umbilical arteries of a fœtus just born, the carotid or other trunks of an artery in a living animal produces nothing like inflammation: after some pulses & a tumor suddenly arising, but not encreasing much, the blood turning from the ligature betakes itself into the neighbouring lateral vessels which will pour out more blood for cutting them, but it will leave the proper trunk empty & which will shortly coalesce with the remaining little blood. In small & pellucid vessels in w^ch the microscope can discover what is doing a ligature produces the opposite effects to what is the commonly received opinion, for the blood is so far from distending the tied vessels that it avoids the ligature & impervious branch betaking itself to the communicating branches till that one which is tied up is left quite empty.

Of the arteries

Ever intent upon making useful observations, Haller has often examined obstructions in a living animal; sometimes the blood is squeezed together, the globules whereof were confused as it were into one mass; sometimes the force of the blood remaining, sometimes disengaged so as to be expelled through a wound or incision made into the artery or vein; if that is not done the blood rests in that place & is collected as if it were attracted to the coagulated cruor. He likewise also beheld obstructions where a great quantity of white humor has stuffed up the artery or vein, nature then attempts never any thing against that kind of obstruction, nor is the blood accelerated towards that place, but runs through the coagulum by some few passages or comes to a state of entire rest in the whole trunk. It is common for the blood to be stagnant & immoveable in the arteries, then that blood that comes new from the heart does not beat against this obstacle but rather being repelled it returns towards the heart & does not dilate the obstructed artery. In a particular case when a viscid matter had obstructed one of the carotid arteries neither

was the diameter of the artery greater under that coagulum
nor were there any redness or signs of inflammation. Wherefore
Haller thinks that the cause of inflammation is quite different
from an obstruction, whether it happens from any stimulus
as many phenomena & those of the eyes being inpitated as is
shown in Whytt's physiological essays give us room to conjecture,
or whether the nature of this disease is not sufficiently known

Lastly there are many things which forbid us to admit
many orders succeeding one another of vessels continually decreasing
In the first place it is but reasonable to allow that san-
guiferous veins should be most readily filled thro' a red artery
as they are formed to carry red globules & have a larger capacity
than any of the arteries of the smaller kind; of course a
colored liquor must pass more difficultly into a yellow or
serous artery than into a vein as being of that order of arteries
which is next in size to red ones & smaller than red veins, but
more readily than into other vessels of still lower orders, hence
a lymphatic artery, or one that contains only a pellucid fluid,
will more difficultly admit any liquor impelled into it, for

such a liquor can never penetrate so far as to come at it
till it runs thro' the whole length of the red as well as the
yellow artery in its way to the pellucid one. This difficulty
will be alsg increased as well from the narrowness of this little
artery as from the retardation which the said liquor must
suffer in the yellow vessels which are both ramifying and
conical; but if we speak of blood globules & their course
through smaller vessels, a red globule could very seldom & very
difficultly pass through the whole length of a yellow artery
whose largest capacity is less than that of a red globule, but
the narrowest & ultimate ends cannot but be manifold
narrower than a red globule, seeing the yellow or second
order of vessels are conical & their capacity continually diminishes
wherefore it is scarcely credible that the force of an impacted
globule will be so great at any time, or the celerity of a colored
liquor such, that it should penetrate through a conical canal
converging its whole length & much narrower than the globules
of it so as to get into the pellucid vessels. But experiments
shew nothing like this, for water, & saline salts dissolved in spirit,
the

the oil of Turpentine, tallow & wax very easily enter into the pellucid vessels, as easily at least as into a red vein or into the yellow arteries if there are any such, which are continued from sanguineous ones. It has been shown already that all those liquors we have mentioned pass very readily into the adipose cells, & that more readily than into red veins. With near the same facility the exhaling vessels of the stomach & intestines, & those which pour the vapors into the cavities of the pleura, the pericardium & brain may be filled by the same injections. All those pellucid vessels I say, are filled with equal or greater facility through the arteries than the red veins are, when many of them nevertheless do carry a liquor in them much more subtle than the yellow serum, although from Boerhaave's hypothesis they do not therefore arise from red but from yellow arteries, or else from other orders of vessels still more remote from red arteries.

A stronger argument is taken from the blood itself. It seems conspicuous with that hypothesis which supposes successive series of vessels, that the blood should come but with the utmost difficulty

difficulty into those pellucid vessels, & yet that event is common & innocent enough & has been already confirmed by instances we have brought to prove it. For the blood does frequently and easily penetrate through entire vessels that are not ruptured or suffered any violence as those of the kidneys, uterus, skin, & therefore passes by an easy & short way from the red arteries into the pellucid excretory ducts of almost the whole body, therefor it does not appear that these vessels are distant from the red arteries by the intervention of any series of conical arteries.

Lenac who does not however seem to defend the theory of Boerhaave or these successive orders of vessels denies that the very slender & fine vessels can proceed immediately from red arteries, seeing according to this hypothesis there is great danger that these very tender vessels should be ruptured if they were exposed to the impetus of the blood. That they are not so tender however is easily shewn, since they sustain the great force of the anatomists with his syringe, the weight of Quicksilver & the injection of tallow & wax which are fluids

thicker & more ponderous than blood with all the labor of the muscles & weight of the impelling blood to force them on, & that easily and without rupture. Moreover as Boerhaave supposes the smallest red artery to serve as an aorta to the yellow artery next in order, & the ultimate branch of this to serve again as an aorta to a lymphatic artery; since all these arteries are likewise branching & conical, & liable to suffer the same decreases in the velocity of their humors which arise from the branching & conical nature of red arteries. since in the ultimate end of a red artery, according to that hypothesis a liquor flows but very slowly, it follows that the slowness of motion in the pellucid vessels will be exceedingly great, as they are separated from the red arteries by the intervention of many orders of vessels in the supposition of Boerhaave.

Suppose this retardation to be exactly the same in every different series of vessels; suppose the retardation which happens in the smallest artery to be such that at least the blood shall flow from its ultimate branch, but with a

twentieth part of the velocity with which it comes from the heart; it will then flow through a small artery of a tenth order with a velocity which will be to the velocity of the same fluid in the great aorta just as it rises from the heart as unit to the tenth power of the number twenty (ten being the number of orders & twenty the difference of velocity in each) The number twenty carried to its tenth power are three hundred millions of millions. Suppose then that the blood in the beginning of the large aorta has a velocity which moveing uniformly would carry it through one hundred & fifty feet in a second of time, which it is computed to have, then in the tenth sized artery its velocity is so diminished that it has no greater a velocity than what would in a like second of time carry it through less than a hundred millionth part of a foot. Suppose the velocity of blood in the aorta as it comes from the heart to decrease continually in any other ratio it is well known that the decimal powers of the smallest numbers will be very great indeed.

Now, nothing of this kind happens in the Body, & the course of the fluids in the very smallest vessels we know is gone through with celerity, equal indeed to that of the blood itself, if not greater, as in the insensible perspiration as it is called, when made visible by art, or the fluid which passes through the nerves, for example, & which conveys the impressions made on the senses to the brain.

The illustrious Lenæ replies in answer to this, that the finer fluids are not much retarded. But that retardation which happens from the increased capacity of branches above that of the trunk & the friction arising from that, I say these diminutions of velocity are always the same whatever you suppose the fineness of the fluids to be or whatever is their specific gravity.

Of the veins

This class of vessels was more universally known amongst the ancients than the arteries & more examined; for as they supposed the seat of diseases to be in the veins & therefore very frequently opened them & wittnat imagined that the place in which the section was made produced very different effects. they certainly must be much more anxious to obtain a knowledge of them than of the arteries.

In the human species & other animals having red blood the veins make a distinct class of vessels being similar to & every where accompanying the arteries & in like manner arising from the heart. They differ from the arteries universally, especially in a physiological sense, in the course of the blood in them.

There are commonly reckoned but two trunks of veins arising from the heart as there are but two arteries proceeding therefrom viz: the vena pulmonalis & the cava; but upon more attentive examination we find that there are six venous trunks which never come together unless at the two auricles of the heart, viz: 4 pulmonary veins & 2 cavæ. At the heart all the veins are very large, but as they recede

therefrom gradually grow smaller in like manner as the arteries.
The ancients therefore were very right in saying that the
veins arose from the heart. Galen however considered the nature
of their origin otherwise, & derived it from that part in which
they receive the blood; in this he was followed by Aretæus
Fallopius and others.

We omit here the vena portarum which differs not only
in the manner in which it distributes its contained blood, but
in its fabric from all the other veins & will be treated of in
the history of the Liver.

The vena cava that accompanies the aorta was known
by that name to the ancients. From the two cavæ all
the parts in the human body have their branches except the
lungs.

The veins are conical like the arteries. For the two cavæ
are very large at the right auricle the superior of which sends
branches to all parts of the head & superior extremities & the
inferior to all parts of the abdomen & inferior extremities; hence
they universally become smaller as they pass on till the ultimate
capillary veins are cylindrical in like manner as the arteries

Of the veins

The diameter of the veins is much more inconstant than the arteries; however they have this law in common with the arteries that the lights of any two branches taken together is larger than the light of the trunk from which they proceed. wherefore as the capacity of the aorta is much less than that of all its branches taken together so the same may truly be pronounced concerning the light of the vena cava when compared with the sum of the lights of all their branches

The interior fabric of the veins is more simple than that of the arteries, & differs from them in not having that solid tendinous compages which makes the principal coat of the arteries & wanting entirely the transverse muscular fibres that appear so evidently in the arteries.

The internal coat of the veins is smooth & polished like that of the arteries but more flexile & without fibres or pores.

The middle coat is more obscure in the veins than in the arteries, & tho' it is muscular in the cava near the heart where they pulsate & by their contraction force the blood into the right auricle; yet as contraction is entirely wanting in the other trunks

so we are not to admit of any contractile fibres in the veins until they are demonstrated by experiments. There are however in this membrane red flexible fibres which go longitudinally of the veins.

Over this coat as in the arteries is a cellular one but thiner than that of the arteries; on this is incumbent the pleura, pericardium, peritoneum &c: forming the exterior partial coat of some of the veins in like manner as we said of the arteries.

Besides, the venal trunks are furnished with small arteries & veins that run thro' its cellular coat in the same manner as in the arteries. That they have nerves also we may deduce from analogy tho' it cant be assumed from experiments. for typing or pricking the veins dont appear to excite pain, nor are they but little irritable or elastic.

The strength with which the veins resist being ruptured is greater than one would at first imagin, for their coats are much thinner in comparison to their capacity than that of the arteries. The thickness of the vena cava descendens to the aorta according to Kiell was as 97 to 518 that is in nearly a subquintuple ratio, but the accurate Wintringham makes the ratio in men as 9 to 154 that is in a subquadruor decuple proportion.

Again, the ratio of the fluids to the solids in the vena cava near the origin of the renal veins was as 1000 to 1594, & in the renal veins as 100 to 2702 when in the artery it was as 1000 to 2027; wherefore the coats of the renal veins are in thickness when compared with their contained fluid to the thickness of the solid part of the arteries compared with their contained fluid in a ratio which is as 2027 to 2702 that is in nearly a subtredecuple ratio

Moreover, the density of the veins seems to increase in an inverse ratio to their capacity, for the ratio of the solid part to the fluid in the iliac veins is to the same ratio in the renal veins as 552 to 100 & to the same ratio in the splenic vein as 556 to 100.

Therefore the veins have coats universally thinner than the arteries in nearly a quindecuple proportion, yet so that they increase in thickness as they pass on, nor can there be any universal ratio assigned between the solid parts of the arteries & veins. They are so thin however as to collapse by the pressure of the atmosphere when empty except those of the uterus & liver.

Of the veins

Though the coats of the veins are so thin yet they are remarkably dense & are in specific gravity somewhat greater than the coats of the arteries. Thus the specific grabity of the vena cava in a youth was to that of the aorta as 26 to 25 in an old subject as 140 to 139. These experiments prove that the coats of the veins are universally more dense than those of the arteries, but that ratio is diminished by age

The strength of the veins also for the most part exceeds that of the arteries, or, which is the same thing the veins will bear a greater distention than the arteries without bursting as they give way easier and are dilated more than the arteries. Nevertheless in a living animal especially the human the veins more frequently swell & burst than the arteries many instances of wch may be seen in Haller.

It was long since known that the diameter of the veins is greater than that of the arteries, one only excepted, the pulmonary vein. The capacity of the other veins every where is greater than the capacity of the arteries and their contents are as their capacities when their lengths are equal.

Borellus estimated the whole venal area to the whole arterial

ora as 4 to 1. Franciscus de Salvages makes their capacities as 9 to 4. Haller by comparing the ratio of the veins in the different parts of the body to that of their corresponding artery thinks at a medium the ratio of the lights of the arteries & veins is nearly as 4 to 9.

Anastomoses. There are found larger & much more evident anastomoses between the venal than arterial trunks, large veins often uniting in places where the anastomoses of the arteries is effected by very minute twigs. Thus between the jugular vein of the face which is from the internal & the temporal branch of the external jugular there intercedes a trunk communicating at the edge of the inferior maxilla. Between the veins of the arm, the vertebral & temporal & many other veins there are evident anastomoses.

Valvulæ. The valves make a remarkable difference between the arteries & veins, we shall treat of them therefore before we speak of the terminations of the veins.

These valves were little known to the ancients, and Eustachius seems to be among the first who had any adequate idea of them

Of the veins

Hyeronimus Fabricius ab Aquapendente a pupil of Falopius's in his splendid work de venarum ostiolis has well described & depictured the valves which since have been more generally known to anatomists

The venous valves are every where made from the internal coat of the veins which is produced from the part of the vein that is more remote from the heart upwards towards the heart & inwardly into the cavity itself of the vein being reflected back on itself so as to form a lunated margin attenuated to an edge continued downward parallel to the former side to the part more remote from the heart & is then reverted into the internal coat of the vein. So that they are made up of two foliola or lamina first ascending towards the heart then doubling round and descending in the manner above described.

The valves are universally thin as being made of the very thin internal coat of the veins, nevertheless they are of considerable strength & of a shining or tendinous appearance.

The figure of the valves every where is that of a parabola

the convex apex of which is downwards or more remote from the heart & its sides or two receding parts are produced into the cavity of the vein towards the heart, so that between the valve & side of the vein a small space is intercepted which some call a sinus & when filled with wax resembles a para: bolic cone sometimes longer & sometimes shorter but generally longer than a semicircle.

The number of valves placed together are not every where the same. In the larger veins which receive no branch they are generally double. Thus are two at the ingress of the internal jugular vein into the subclavian vein, two at the beginning of the iliacs, two in the trunks & larger branches of the veins of the arms & thighs, two in the vena azygos and Fabricius saw two almost every where. As often as thus are two they are generally equal & when extended entirely shut up the whole cavity of the vein.

These valves more rarely occur, nevertheless they have been seen in the crural vein, Morgagni says he saw treble valves in the jugular vein. Pitcairn & Bidloo have also

pictured treble valves. There are single valves also as in most of the small branches of the veins of the hands and feet, Haller saw solitary valves in the spermatic vein and in the vena vine pap.

Valves for the most part are found in all the veins of the arms, feet, penis, spermatic veins, jugular veins & vena vine pap. in some of the transverse veins as in the subclavian vein, and in most of the veins near the surface of the body. but in those veins that lie deep & in the veins of the viscera there are scarce any to be found, as we are told by Harvey, Senac, Haller & others.

It now only remains that we speak of the endings of the veins. One well known termination of the veins is at the two auricles of the heart, but the other end of them is multiplex nor is it every where to be seen.

It has been said that from the red arteries similarred veins are continued. It does not appear probable that any arise from excretory ducts altho' some of those ducts may every where be inflated by the veins, especially the ureter & hepatic duct.

Of the veins

But there is another principal origin of the veins from cavities into which arteries exhale something. Some of these veins reconvey blood itself, as for example, the veins of the penis, clitoris, cavernous body of the female nipple, & tela cellulosa which is under the skin of some animals which have a red corse or gills. Some return a humor different from the blood. But as there is a multiplex exhalation so there is an equal number of genera of absorbent veins as from all the circumference of the skin, from the subcutaneous cellular membrane & that of the lungs, from the large cavities of the human body, from the passages of air, aliment, urine & semen, also from various glandular follicles & crypte: experiments convince us that veins are connected with all these cavities.

That there is a free passage from the cellular substance under the skin into the veins appears from experiments as from the resorption of fat as well as other liquors effused into those spaces being returned into the blood: air effused, the water in an anasarca, humors artificially forced under the skin, and even blood itself which in a sugillation has stagnated

in the adipose cells returns into the blood after being resolved to a serous temity.

Reason itself without experiment would persuade us that the vapor effused into the larger & smaller cavities of the body is absorbed by veins & returned into the mass of blood. for if something perpetually exhales from the arteries, even if it was ever so slow yet it would gradually accumulate so as to destroy the animal unless there was some way by which it may find an exit from those cavities. (Dr: Haller)

It is evident that red veins take their rise also from smaller veins carrying a thinner fluid; for the pellucid veins of the uvea & more pellucid ones of the vitreous humor and crystalline lens of the eye run into red veins.

Whether do red veins also proceed from lymphatic vessels? Certain it is that the lymphatics may be filled with air every where by the red veins. Haller however does not admit of red veins proceeding from the lymphatic vessels.

Of the lymphatics

The first inventors of the lymphatic veins collected their opinions concerning their origin and use, solely from phenomena observed in living animals

Those celebrated anatomists which followed after them added thereto various experiments and observations made after death with great care and subtlety in order to search out their origin. Among these Malpighius excell'd, who nevertheless, after he had made many accurate experiments, in his manner, durst not pronounce any thing certain concerning them: but that it appeared very probable to him that they arose from small glands as from fountains; yet he declared, he could not evidently arrive at their first origin (b)

after Malpighius, Nuck employ'd great labor in this subject, & having forced air & quicksilver into the arteries and red veins, saw the lymphatic vessels filled, which convinced him that they arose from them; but when he had observed that air forced into the splenic artery rose up into many vessels

(b) Malpigh: de structura glandularum conglobatarum

small vesicles on the outside of the spleen, & that lympha-
tic vessels proceeded from the same vesicles that were
turgid with air; he began to imagin that they sometimes
drove from intermediate cells or vesicles, but where they
were wanting, immediately from the artery itself or vein.(c)

Lastly, Cowper having impelled quicksilver from the
sanguineous arteries & veins into the lymphatic vessels,
ejecting the follicles, he did not doubt but they had
their origin both from the arteries and veins.(d)

All anatomists of those & of more modern times
have agreed in sentiments with these celebrated authors,(e)
and have endeavored to illustrate the doctrine by many
and various reasonings and experiments.

(c) Nuck in adenographia p 52. (d) Cowper in introduction
to Bidloo's plates p 5.

(e) Diemenbroeck in anatomy cap, 22. Sister de humoribus c. 20
Berger in physiol: medica p 78. Valer. Keil in his anatomy
§9. Boerhaave in institut: med: §246 ad §250. Haller in his
notes on Boerhaaves instit: §246 & in prim: lin: physiolog c.8, §181
Cheseldon in his anatomy chap: 10. Nicholls in compend: anat:
prælect: 13. Bianchus historia Hepatis p 920. Sientaud &c:

Of the lymphatics

The younger Monro however has ventured to dissent from so commonly a recieved an opinion whether rashly or no will appear from a careful examination of all the experiments and observations that will be offerd on both sides

Therefore we will first consider some of the theoretic arguments arising from the appearances of the lymphatics.

Then we will examine the various experiments, in the order we shall propose them, by which they endeavor to prove that there are invisible lymphatic arteries from which the lymphatic veins recieve their liquor and see what conclusions may be drawn from them.

Lastly we will endeavour to show that there are absorbent valvular lymphatic veins to be met with in many parts of the body.

(A) It is allowd by all authors, especially the great Boerhaave that the Bartholinian lymphatic vessels as they are called, are veins, they argue in the following manner. "There is no vein but ought to have its artery, that is, that no vessel bears its course towards the heart but what recieves its refluent liquor from another vessel; for any

liquor that moves towards the heart ought first to have been taken from the heart; therefor a vein must have its liquor from other vessels, and for the same reason the lymphatic vessels which take their course towards the heart should recieve their liquor from other vessels. but these other vessels cant be veins for the veins recieve what the arteries bring to them. Therefore the lymphatic vessels out to recieve their fluid from the arteries as all the veins do; hence, as we see that there are lymphatic veins, so it is necessary to suppose that there are lymphatic arteries though invisible from which the lymphatic veins recieve their fluid (f)

But who does not see that the first sentance of this argument is begging the question, for if there can be no vessel running towards the heart, but what recieves its effluent liquor from another vessel, then certainly there must be lymphatic arteries. But no one is ignorant of there being inhaling veins almost through the whole body which by no means have their origin from arteries

(f) See Boerhaaves meth: stud: med: by Haller & his medical institutes

and indeed Boerhaave himself mentions them every where in his works.

(B) It appears very probable from the colour of many parts in the human body, from dissection, microscopic observations, injections, inflammations, & lastly from the nature of the thing, that there are many arteries carrying a pellucid liquor more subtile than red blood; and hence it may appear very probable to some that there are valvular lymphatic veins which bring back such humors as they recieve from these arteries.

But this ought by no means to be granted, unless it is first demonstrated that these pellucid humors are returned by no other veins to the heart: either by showing by experiments the connection that is between the lymphatic arteries & valvular lymphatic veins, or evincing that the latter cannot have their primary origin from any other source.

Not only inflammations & injections demonstrate that there are pellucid humors which return into the mass of blood by veins destitute of valves; but its even

a doubt whether there are any valvular veins in the brain where there are many arteries perhaps more subtle by far than in any other part of the body; at least the most accurate modern anatomists have sought for them there in vain[g]. Hence from the analogy of those parts we conclude that there are humors thinner than red blood in the other parts of the body also which are returned into the sanguineous veins by pellucid veins but destitute of valves.

Concerning the 2.d & 3.d propositions we shall treat more fully hereafter in the order proposed.

(6) They contend also that such arteries must necessarily have lymphatic veins answering to them that the secretions may go on rightly; as the fluid from which the lymph is taken away becomes specifically heavier, at least for a time, or lest the lymph should be too abundant in the sanguineous veins from the diminished motion in them.

There is no need of bringing many arguments against hypotheses of this kind which have of late been

[g] Cowper in introduction to Bidloo's plates.

the appearance of truth. Its easy to refute it by compa-
rative anatomy. In birds, for example, there are nearly
the same secretions as in men, the motion of the venous
blood in them is also slow, yet they have no valvular
lymphatic vessels.

(D) It is observed that the motion of the lymph con-
tinues for some time after death. Authors explain the
reason of it thus, viz.[t] that after death the left ventricle
of the heart continues to pulsate longer than any blood
is transmitted to it from the lungs. But if no blood is
transmitted to it, pray what liquor does it expell? If
it expells any why does not the motion of the blood in the
red veins also continue? Lastly this hypothesis is con-
trary to the more accurate observations of the illustrious
Haller (l). But if you suppose that the lymphatics
inhale then the reason of the thing will appear by no
means so obscure. For as long as the contractile power of
the vessels & animal fibres remains, which is as long
as the animal continues warm, the absorbed humors

(k) Lister de humoribus. (l) v. Haller Exp. in act. Gotting: tom: i

continiw moveing on from the patulent mouths of these vessels.

(E) Nuck observes that water injected immediately after death while the animal remains warm, the lymphatic vessels may be very successfully filled: but it has not been observed by Nuck or any other author of veracity that I know of, that the other veins of the body are so happily filled immediately after death, the reason of which is, because they are continuous vessels: but from what has been said it clearly appears that the cellular cavities of the body being inflated with water is greedily absorbed by the open mouths of the lymphatic veins & promoted by the contractile force of the parts

(F) The other veins which we know certainly are produced from arteries, are furnished with valves only in those places where they are exposed either to the uncertain actions of the muscles, the pulsations of the arteries, or where there is danger lest by strong external compression the progress of the humors should be impeded towards the heart: hence the veins of the encephalon, thorax and abdomen in general

are without valves [n]. But the lymphatic veins not only in their large but small branches as far as ever I have been able to trace them, & from their great analogy with the lacteals [o], are no doubt furnished with very evident valves from their very origin [p].

But we ought to consider what so many valves can effect, in order that we may more clearly perceive the cause of so singular a fabric. For it is but obscurely explained by physiologists. Many indeed have explained the use of the valves in general, but have left these vessels untouched [q]. Some

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[n] I say in general, for valves are found at the mouth of the coronary veins, of the inferior cava at its insertion into the auricle of the heart, in the spermatic veins & in the vena azygos

[o] An opinion has prevail'd among anatomists that the lacteals are valvular only after they have receded somewhat from the intestines. Haller also favors this opinion physiol 6 720. I know not from whence this error arose for in those subjects in w.ch I fill'd the lacteal vessels running between the coats of the intestines w.th mercury & other fluids I met with a great number of valves which strongly resisted the retropulsion of the fluids.

[p] It is said that the cel: Fenwick demonstrated stimulated lymphatic vessels on the surface of the lungs, but he is the only one.

have treated of them in expres words but seem to have entirely
missed their true uses. Thus Nuck conjectures that the valves
are destined equally to their dilatation & contraction. Lister
and Berger consider the valves of the lymphatics as so many
small muscles continuing the motion of their impelled fluids.
And not long since the celebrated Hamburger rejecting the
opinions of others concerning this matter, imagined that he
himself had first discovered their true use, which he thus
explains viz: that the sides of the lacteal vessels are very
weak & thin so as to prevent the adhesion of the chyle acting
on the villous coat of the intestines, by which means the chyl-
iferous vessels are filled & opposed from their sides; hence they
are furnished with frequent valves by which their otherwise
too weak coats are strengthned & their too great extension
impeded: But he does not reckon the valves among the causes
that determine the motion of the chyle, because he imagins
there are other powers sufficient to hinder its retrogression.
But if these powers were not sufficient, only one valve placed
in any trunk of the lacteal vessels proceeding from the intestines
would be all that would be necessary: therefore all or the

the greatest part at least of the rest would be superfluous.

But this does not seem a sufficient cause why the sides of the lacteal vessels should be so very thin and weak; nor do experiments or their spontaneous evacuation after death demonstrate them to be so weak. But granting that their coats ought to very thin and weak, it do no wise agree with the simplicity & wisdom of nature to make use of so many folding values for strengthning them. For these if they dont assist the progress of the fluids must needs hinder it, by being in the way of the fluids that are seeking entrance. Therefore sphincters or tendinous fibres placed round their external coats would much better answer that end. Besides in whatever place there is the greatest quantity & velocity of the circulating fluid & of consequence the greatest distention of their coats as in the thoracic duct there should be the greatest number of values; but the values there are distant from each other by much greater intervals, so that I scarcely ever saw above eight or nine pair of values in it.

But truly there is no need of having recourse to these obscure causes, since the course of these vessels is so particularly

disposed as to be acted upon by the strokes of the circumjacent
arteries, & the actions of the muscles. the thing itself points
out to us why they are furnished with valves. If they
were compressed thro' their whole tract in one & the same
time, then indeed, one, or a great number of valves would
have the same effect. But as they pass along the arteries
only for a certain space & the external pressure is applyed
sometimes to one & sometimes to another part of the vessel
so that if the valves were placed at great distances from
each other, from the largness of the intercepted spaces, the
length of the fibres & the ease with which they would thence
admit of extension, they would scarcely contribute any thing
towards assisting the progress of their contained fluid. For
any vibration or compression communicated to a great space &
hence from its largness divided & diminished would be unfit
for propelling the fluid beyond the first pair of valves. But
the more valves there are & the closer they are to each other
in proportion will be the effect of external compression increased
nearly. For the least force striking on those very small spaces

will force on the fluid through the first valves which will then prevent its reflux or return; for this end they are furnished with very frequent valves that every pulsation or percussion of the adjacent organs, though small, may force on the lymph.

This is not only consonant to a just method of reasoning but also to experiment, for a lymphatic vessel filled with mercury can scarce be touched with the hands but the mercury is propelled & ascends upwards; whereas a red vein which has fewer valves requires much stronger percussion & compression in order that the same effect may happen. From this also it appears why the thoracic duct is furnished with but few valves, as it ascends near to, & almost parallel to the great artery & hence a great portion of it is acted upon in the systole of the heart at one and the same time.

From what has been said it appears evident that the lymphatic vessels stand in need of external force in order that their contain'd fluids may be propell'd onward. But it is no wise congruous with truth or probability that they stand in need of such assistance because of the thinness of their liquor & subtlety of their origin from the arteries & of consequence a defect

of the powers & motion of the heart; for the arteries of the
encephalon in particular are dispersed into branches so small
as almost to exceed imagination, & contain a fluid much more
subtle than the lymphatic humor, & perhaps the subtlest in
the whole body; but that is in no wise assisted in moving
onward either by the pulse or contraction of the arteries of
other places of the body, because their coats are vastly more
thin than in other parts & have very little if any pulsation,
neither is its progress assisted by the vibrations of the muscles.
nevertheless the veins answering to these arteries have no valves.
Nor indeed in the excretory ducts of the glands where the motion
of the liquor is so very slow are valves found; for if nothing
hinders the liquor injected into those ducts is readily forced
into the arteries. From hence it is evident that the motion
arising from the division of the arteries into small branches
does not become so languid as that nature is forced to make
use of valves in order to direct & promote the course of the humors.
Hence the great number of valves in the lymphatic veins
seem to indicate that these vessels are in no wise formed from

reflected arteries but that they are a system of inhaling veins in which the humors are urged on towards the heart by the contraction of their coats & the pressure of the adjacent parts; but do not derive the primary motion of their fluids from the force of the heart pressing à tergo.

(G) If the lymphatic veins arose from reflected arteries, why are they not also in the brain?(y) But as external compression which is sufficient for propelling the absorbed liquors appears to be wanting within the cranium, perhaps for that reason they are also wanting. But its more than probable that it affords some that for absorbent.

Let us now proceed to examin the experiments of celebrated anatomists by which they have so plainly & indubitably demonstrated that there are lymphatic arteries answering to those veins, that they are of opinion no way can be found to overthrow it by proper experiments, or confute it by argum:, viz:, they have found that air, water, mercury, & wax injected

(y) Ridley indeed, & some others boast that they have seen lymphatics in the plexus choroides. But its very probable they were hydatides wch are not rarely found there & appearing like lymphatics deceived them.

into the red vessels returns through the lymphatics which no one ever suspected could otherwise happen than by a connection or anastamoses of the vessels.

But if we attend to the experiments just as they are related we shall find quite a different reason for the filling of the lymphatic veins, which we shall therefore consider.

(H) For Ruck who, by his industry, the number of his experiments, & his faithfull enarration of their event is most to be depended on in this matter, in that chapter of his adenographia where he gives us his opinion concerning the origin of the lymphatics, says "air forced into the splenic artery raises many small vesicles on the surface of the spleen & the lymphatic vessels proceed from these same vesicles which he also saw turgid with air" from which it appears that Ruck was of the opinion that in the spleen they by no means arise immediately from arteries but from intermediate vesicles. But pray what vesicles are these? for I know of no others so conspicuous as to be seen with the naked eye but the cellules of the cellular web; & air forced

now

more strongly into the splenic artery which and the very woods of Nuck do easily rushes into the cellules of this tender viscus that no one is ignorant of it that have made the experiment. Hence it will appear from this experiment, unless the air perhaps entered the lacerated branches of the lymphatic veins, that they have their primary origin in the spleen from cellules, that is, that they are inhaling veins.

If The very accurate Morgagni having thrown air, which as he rightly observes is what Nuck made use of, into the splenic veins tells us that he filled the lymphatic vessels creeping along the surface of the spleen. Tho' this at first thought may appear a strong argument against us, yet I will not only remove it but endeavour to show that it will afford a strong argument for the support of our opinion. For while I attentively made the experiment I observed the following phenomena.

a Thin ceraceous matter being injected into the splenic artery shewed it to be divided into very small branches. Air injected passed into the cellules: but before it passed into them it did not enter the lymphatic vessels, nor indeed did the

trunk of the splenic vein appear to become turgid through the
boad sinus in the longitudinal direction of the spleen.
Mercury injected refders this more obvious to the eye.

But wax, mercury, or air being moderately, nay very
gently forced into the splenic vein immediately enters all
the cellules of the spleen & give it the appearance of cellular
bladders as if its membranes had been punctured & a little
tube inserted into the cellules: but they find a retrograde
passage into the branches of the artery with the greatest
difficulty. The trunk of the vein sin an ox being cut thro
its whole length, its coats are every where very pierced
with foramina through which the red parts of the spleen
protuberate like so many fungi. If air is emitted into
one of these foramina kept in the same direction of the
trunk of the vein, it passes behind its trunk & immediately
enters through another; but if it is injused in a transverse
direction it enters the cavities or cellules which communicate
freely & mutually with each other. A Probe being cautiously
run into these foramina & the spleen being cut we discern
a red or darkish substance covered with a very thin membrane

which somewhat resembles the internal membrane of the auricle of the heart in some animals; but which has hardly any similitude with the coats of the veins in other parts of the body. Nor do you discover a regular series of branches but rather cavities communicating for every side & which when filled with air dryed & cut open discovers irregular cellules. Warm water injected into the splenic vein & so into these cavities & the spleen gently handled & pressed fills the lymphatics running on its surface & between its coats: for in calves it is circumdued with a double membrane, from whence perhaps arose the vulgar error of there being a double membrane to the spleen in the human species. But I never saw those that run between the coats filled before by injecting with air; that however is more clearly evinced by injecting mercury. Hence water perhaps also first penetrates between the membranes before it enters them. Tho' whether that happens or not I cannot say. Air or mercury injected between the coats of the spleen very successfully fills the lymphatic vessels but this

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is clearly & indubiously discerned to happen through the lacer=
=ated branches.

In these lymphatic veins where they leave the spleen & accompany the large blood vessels there are valves which hinder the retrogression of the fluids: valves are also found between the membranes on the surface of the spleen, but more sparingly, so as scarcely to deny a free passage to the fluid in every direction; hence air blowing forced into one branch running along the surface of the spleen, the great plexus of lymphatic veins surrounding that whole viscus become conspicuous; but I could never force a fluid from this plexus into the cellular cavities of the spleen or into the splenic vessels; from hence it appears that there are valves at the beginning of those vessels which serve for directing the course of the humor. In the plexus on the surface they are perhaps not so frequent, because the equable pressure in respiration promotes the course of the humor in all of them at one and the same time: besides there are many large vessels there which they accompany & surround so that

the humors may be propelled onward by every stroke of the arteries.

The spleen being cut open, many whitish corpuscles are observed; these mr Leeuwen by Malpighius taken for glandules.

From what has been said it is evident that the experim^ts adduced by authors do not in the least prove that there is a strait commerce of the lymphatic vessels with the splenic arteries or red veins; or that there is an anastomosis of their branches; but rather render it very probable that they absorb their humors from the cells of the spleen.

[K] But it may be asked what is the reason that mercury enters the lymphatics so easily when its parts are so tenacious that it can scarce be propelled from the arteries into the red veins. For no one I believe will deny but that if the lymphatic veins proceed from the arteries they must be much smaller than the red veins[c]; or if the passages are so open why does not the red blood also find its way there in the

[c] For if it is true that there may be ten globules in lymph, 36 of which make one red globule: of consequence, the diameter of a red globule or of the ultimate red artery must be much more than three times the diameter of a lymphatic globule or the extreme lymphatic artery.

living animal? There is hardly any one now that would answ^r with Ruck that this would prove noxious or that it is owing to the various figures of the pores & particles. for these have long since been rejected.

(2^d) But an experiment of Cowper's from which is drawn the strongest argument concerning the origin of these vessels has made the subject appear much more obscure; he often tryed to force mercury from the spermatic artery into the corresponding vein, or, from the vein into the artery tho' without succes: but the mercury readily penetrated from the spermatic veins into the lymphatic vessels: from which therefore it appears, that either the passages between the spermatic veins and lymphatics are more patulent than between the same vein & its correspondent artery from which nevertheless it recieves the red globules of blood as these in a living sound animal are never found in the lymphatic vessels of the spermatic cord; or, that by the too great pressure of the mercury the vein was ruptured & then it insinuated itself into the lymphatics.

This I have often seen happen but not in that manner. For when I increased the height of the mercury by an instrument

sufficiently long I at length forced it from the spermatic
artery into the spermatic vein, but if there was no rupture
of the vessels or effusion of the mercury the lymphatics re-
mained empty; but being ruptured either accidentally or
designedly it readily penetrated from the branches of the
artery within the coats of the testicle into the vein; but
the lymphatics were speedily filled with the mercury and
became conspicuous.

From this experiment we have a solution of what
has deservedly been looked upon as a paradox by some viz:
that liquors being thrown into the red veins fill the lymphatic
vessels; for it matters little whether the fluid is injected
into the arteries or veins, if these can be filled only by
extravasation.

Nuck by observation beheld, in his theory of the
various figures of the pores & particles, what from the received
opinion could hardly have happened, viz. That mercury tho'
very mobile injected into the splenic artery in no wise
entered the lymphatics of the spleen, when nevertheless air
forced into the same artery distends them without much

difficulty, tho' air will not enter into various other parts in which mercury finds a ready passage. For if the lymphatic vessels were produced from the reflected branches of the arteries, then a very subtle & thin fluid whether air or mercury would always & every circumstance readily penetrate into & fill them: But if we suppose that the fluid before it enters them must first pass into the cellules, then, in a viscus of a lax & weak fabric as in the spleen in which the experiment was made, the injection of air which suffices for rupturing the vessels but yet does not too much press upon or lessen the capacity of the lymphatics will most happily succeed: whereas on the contrary in other parts of a more firm & strong compages air will not at all succeed because it cannot be inflated with such force, unless we make use of a machine, as to penetrate into the tela cellulosa, and how mercury by its weight is more fitly made use of.

(N°) a Berlin physician (Dr Desesche) a man skilled in anatomy shewed me the liver of an infant on the surface of which he affirmed the valvular lymphatic vessels could plainly be seen distended with wax that was injected into the hepatic

artery

artery, without any apparent rupture of the vessels or effusion of the wax: but upon an attentive consideration of the matter we may readily discover what it was that imposed this fallacy upon that worthy man. For if the wax entered the lymphatics from the arteries by continuous ducts, certainly the small branches of the hepatic artery would have been compleatly filled. Also both the arteries & branches of the lymphatic veins when filled with wax might clearly be distinguished from each other, for the branches of the arteries are every where cylindrical & equal, but those of the lymphatics are knotty and intercepted with valves which readily distinguish them.

But in this preparation the wax had by no means filled the very fine vessels, but only appeared to have entered the thicker ones. The arteries & lymphatics could not be distinguished from each other; for, if in one part any vessel had the appearance of a knotty lymphatic vein, in another part, or in other branches of the same vessel it appear'd cylindrical without any knotts. Hence it seems evident beyond doubt that this appearance was owing in

some parts only to the aqueous fluid mixed with the injected wax & intercepted between its parts; which not unfrequently happens to those who practise injecting as was long since known & observed. (i)

(b) Diemerbroeck & Heister say that the lymphatics of the liver become turgid in a living animal by applying a ligature round the vena portarum. But this experiment is so far from proving that these vessels proceed from the sanguineous ones that it shows quite the contrary. For the vena portarum may be looked upon as the greatest artery of the liver, from which, if the lymphatics proceed from sanguineous vessels, the greatest number of them must arise. But does a ligature of the artery make its small branches become turgid? If you think the lymphatics proceed only from the branches of the aorta that run in the liver they will proceed from the hepatic artery. But a ligature made on the vena portarum will cause a less resistance to the blood hastening from that artery into the branches of the cava: hence a less determination of

(i) See Monro on injecting in Ed: med: ess: 1st Anat: c: 13 Heister's compend:

the fluid into the vena portarum. But if you imagin that the lymphatics absorb, then the reason of the phenomenon will be evident. For from the pain & great anxiety brought on the animal all its powers will be excited: its fibres & vessels will more strongly contract, the muscles will be excited into strong & frequent vibrations, by which means the fluids which these vessels take up at their origin will move with greater celerity; whereat the same time the progress of the lymph will be impeded by the ligature which cannot be put round the vena portarum but the large branches of the lymphatics that surround the same will be included in it.

But they are sooner filled by external pressure than by the increased velocity of the fluid as is provd by Diemerbroeck in the place above cited, for he observed that the intumescence greatly increased if the liver was gently pressed with the hand.

(f) They likewise order'd the spermatic cord to be tyed with a ligature & then the testes to be compressed & agitated

(f) Graaf de vior: org: genital p 36 Diemerb: in anat. c 22.

that their turgid lymphatics may be rendered conspicuous, the rationale of which cannot be explain'd unless in the manner we have just now dric.

2/ Moreover both DeGraaf & Ruysch teach that by light compression & agitation the lymphatic vessels of the viscera even when taken out of the body are rendered conspicuous. But so small a quantity of humor remains in the arteries after death & after cutting out the viscus that it can scarcely be thought, that by compression & agitation it can be urged from the arteries into the lymphatics, but lying hid in the cells & cavities will enter their mouths & be propelled into the small branches, which must thus happen before the following can appear probable. viz:

℞ The spleen of a Sheep being a long while macerated in water Malpighius saw its lymphatic vessels filled and turgid with water: which same was observed by me when I agitated the testicle of a hog that had been macerated for some days in water. Is it probable that this humor first lay hid in the arteries or beginnings of the lymphatic veins but is now forced into the larger branches, for before all the

cellules are inflated with water compression & agitation avail nothing towards filling them.

We read in many authors that mercury or wax forced into the mesenteric arteries has luckily filled the lacteal vessels themselves [o] & they make no doubt to affirm that there is an immediate commerce between the mesenteric arteries & lacteal veins upon the intestines. [p] Hence as they imagin the lymphatic veins are exactly of the same fabric, & not without some appearance of truth, some perhaps may judge that there is a commerce in like manner between these & the arteries; but since it is both so evident & allowed by all, that the use of the lacteal veins is to absorb the chyle from the cavity of the intestines & to convey it into the blood; it is obvious that if there is any connection between them and the arteries, that it can only serve for secondary purposes. In like manner if liquors injected into the arteries should pass into the lymphatic veins also without effusion which however we have endeavored to demonstrate has never yet certainly happened

[o] Tyson of the ourang outang p 35 Cowper on Bidloo's tables 46 Manget in theatro anat: p 668. [p] Cowper in philos: Transact.

it would only show from analogy that there is between these as between the lacteal veins in their progress a commerce & communication of a secondary use with the arteries. But the event of this experiment concerning the communication between the arteries & lymphatics leads us to a conclusion quite the contrary as we will immediately explain.

(I) we have mentioned above that we have very often forced mercury into the arteries by gradually increasing its weight, but never with so fortunate an event as to pass into the lymphatics while the vessels remained whole; but by extravasation the lymphatics may be filled either by pouring the mercury into the arteries, veins, excretory ducts, or into the cells themselves.

That kind of experiment in different viscera & with various infused liquors always afforded us exactly the same event

Concerning experiments made on the testicles of men & quadrupeds we have very fully treated in our inaugural dissertation, and above at the letter (L).

Experiments on the spleen of a calf may be seen at (S).

In the liver also the success was the same, viz: after a subtile but just repletion no lymphatics were brought to view;

but having suddenly & violently forced wax into the hepatic artery of a man, & the vessels being thereby ruptured, the lymphatics creeping along the coats of the vena portarum & gall bladder & situated in the sulci of the inferior part of the liver were twice compleatly filled. But it does not from thence appear that they take their origin from the small twigs of arteries, as the smaller branches of the artery did not admit the wax, & when I sought out their origin with the knife, I discovered no very visible branches; but in various places both in the substance of the liver itself & between the coats of the gall bladder the cellules were full of the effused matter, from which I had been able to urge the wax into the evidently lacerated branches of the lymphatic vessels.

In exactly the same manner viz: by strongly forcing any glutinous matter colored with cinnabar into the aorta of a man I have filled many lacteal vessels of the first kind both of the stomach & intestines running between their tunics.

And indeed I have observed in the anterior side of the stomach an evident plexus of lacteal vessels the small branches of which running together into many larger ones between the

external & muscular coats ascended to its superior curvature & then emerged from the tunics of the stomach. But where they terminate I cannot certainly say; for from the quantity of extravasated fluid I could not follow them any further. But as they are not inserted into the small red gastric veins, & it seems very improbable that they terminate in the trunk of the superior gastric vein; it therefore appears to me very probable that they end in the thoracic duct.

In the small intestines many lacteal vessels received the colored matter. In the large intestines I discovered only one at the superior curvature of the colon of the left side; altho' I know for certain that the large intestines are furnished with many.

These lacteal vessels are valvular as in their course they make a knotty appearance; & this is moreover very evident as I have propell'd fluid matter very easily up to the large branches but could not force it back into the smaller ones. They were undoubtedly filled by extravasation, because they arose only from that place in which the matter was effused, & in some parts the matter only entered the larger branches

branches which also might have been urged into them from the cellules.

From what has been said then we may very safely conclude that there is no immediate commerce betweeen the meserai arteries & the lacteal veins upon the intestines themselves as vomd celebrated anatomists have asserted[1] decieved perhaps by some such experiment. Nor when the ceraceous matter passes from the arteries into the lacteal vessels of the second kind will it be proper to seek for such subtle anastomoses of the small branches. For this may happen by extravasation between the conglobate mesenteric glands &c. is foreign from what I have observed.

These experiments have at least decieved those authors who by injecting fluids into the arteries & thereby filling the lymphatics contend that they have indubitably demonstrated the lymphatic arteries.

But I cant affirm that these experiments at the same time show that the lymphatic vessels receive their primary origin from the cavities & cells, i,e, that their patulent mouths opening into them, fluids injected find these primary fountains

[1] Tyson, Cowper, Mangetus, Tarin &c

from which they rise, & enter them. In some experiments this carries with it the appearance of truth; but in others it clearly appeared that the very tender small branches of these vessels were lacerated & that the fluid found a passage thro the lacerated ramuscula, wherefore it becomes altogether probable that the same also happened in the formed cases. And when once the mercury has entered its easily propelled further and further by the valves.

(W) It is believed that the lympth is taken from the arteries that are next adjacent as it is sometimes found to be of a yellow or reddish colour. This indeed may arise from the ends of the arteries which they conceit are the beginnings of the lymphatics being only dilated or enlarged so as to admit such globules, or, that the lateral branches of the arteries exhaling into the cellules & cavities admit those globules into them. Either of these appear equally probable, & in various parts of the body we know often does happen.

An experiment of Wepfer's seems to confirm that the lympth & chyle may sometimes at least be changed to a reddish color or bloody by extravasation viz. He gave to a large

Dog a drachm of corrosive sublimate at 8 O'Clock in the morning made into a bolus with crumbs of bread. Half an hour was scarcely elapsed before he began to vomit violently; about 9 o'clock he vomited mucus ting'd with blood which was after:wards more & more bloody, & at last blackish. About 6 o'clock in the evening he discharged bloody faeces, afterwards black & pitchy. The next day he found the dog dead in a stable. The thoracic duct & receptaculum chyli were full of a bloody lymph, but the abdomen being opened he found much extra:vasated blood between the liver & stomach in the left hypochon:drium, & also within the duplicature of the omentum about the stomach. The stomach was full of a frothy viscid bloody mucus: the like mucus was seen through the whole intestinal tube: in the rectum the faeces were blacker than pitch.

Having taken away the fibrous coat of the guts & stomach, between that & the nervous coat he found, in many places, extravasated grumous blood, as also in most of the interstices between their coats. In the extravasation of the blood therefore we ought to seek for the cause of the lymph being bloody. For from so vehement a force & so suddenly applyd the vessels were

ruptured & not dilated. But the aforesaid experiments shew that the lymphatic vessels, as also the lacteals may easily be filled by extravasation.

(V) Nor is that a strong objection that prevents itself against our opinion, that the lymph in the valvular lymphatic veins, & the humors in various cavities of the body & on the surface, by no means agree in all their properties. For the greatest and thinner part is taken up by the inhaling branches of the red veins which are scattered every where, while only a certain portion is absorbed by the lymphatics; besides it appears in no wise improbable but that by absorption and passing through these vessels it becomes changed & acquires new properties.

Having considered the experiments and various argu-ments for the existance of lymphatic arteries answering to the valvular lymphatic veins & refuted them; and having de-signed this work not only to overthrow that doctrine, but also to show the probability of their being absorbents. It remains that we demonstrate that these vessels do take up a fluid in many parts of the body.

(W) And, what is greatly to be admired, the very authors who argue so strongly for lymphatic arteries being the

primary fountains of the lymphatic veins. adduce experim:ts which sufficiently evince that they absorb humors from cavities, tho' I dare by no means draw that conclusion from them. Thus Nuck[x] in that chapter the title of which is of the origin of the lymphatic vessels, derives them (if you except what he throws in concerning the lymphatics of the Spleen) in general from the arteries; but afterwards he says that the lymphatics of the kidneys may be filled by the infusion of a fluid into the ureter or pelvis of the kidneys; & further he observes that he has himself seen the success of this experiment exceed his most sanguine expectation, if the arteries and veins of the kidneys were first filled with wax. But there is no one but must see that this could not happen if the lymphatic vessels take their origin from those arteries.

(x) Cowper also makes the origin of the lymphatics to be from the blood vessels, & yet he says that they may be filled thro' the biliary ducts, ureters, & from the cellules of the penis.[a]

(y) The celebrated Ferrein[b] filled the lymphatic vessels of the liver with a fluid injected into the biliary ducts: and

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[x] Nuck in Adenographia. [a] Cowper in introduct: & expl: Tab: 38 &c:
[b] Ferrein histor: acad: Sciences 1733.

indeed he concludes from this experiment that they take their origin from the beginnings of the biliary ducts.

(Y) Moreover Petzer a man of strict fidelity saw the lymph yellow in some animals about the liver to which Kerkringius adds that he has found the lymph not only yellowish but bitter in the lymphatic vessels creeping upon the gall bladder. The same is affirmed by Sylvius and Ravenhorst a clear proof that the bile is absorbed by the lymphatics.

(A A) Both Haller and the younger monro have described a vessel arising from the epididymis which unless it be either a preternatural division of the epidydimis into two branches, or one from the vessels carrying the semen from the testicle going astray from the rest & from the epidydimis & joining at its middle or lower part; which was at first Monro's opinion & which at first appeared probable from some experiments; affords a very remarkable example of the lymphatics being absorbent vessels.

(B B) So great is the similitude between the lacteal and lymphatic vessels that, if we consider the simplicity &

conquity of nature, it will by no means appear probable that the former are absorbent veins but the latter not.

(66) Lastly the following arguments will sufficiently prove that in many parts of the body there are valvular lymphatics that actually do absorb a fluid by their mouths. It is wident also from most of the conglobate glands recieving at least some absorbent branches.

A tumor of the inguinal conglobate glands called a bubo which happens so frequently after impure coition & often invades without any eforion of the parts giving the first mark of the contagion; affords us a very clear & plain example of this.

For if the poison is carried through the whole body with the circulation of the blood, why does it rather affect the inguinal, than the axillary cervical or any other glands of exactly the same fabrik? There is no having recourse to any particular or hidden compage of these glands. For, if any other place is first affected with the poison the inguinal glands are not first diseased, but the adjacent ones placed between that & the heart, as we shall shew by and by.

Therefore the true reason why the infection is carried to

the inguinal glands is the absorption of it by the lymphatics which arise from the genitals. For there is no other avenue to them.

(DD) Nor can this happen from any other cause is proved from nurses who catch the venereal disease by suckling infected children, tumors in the axilla are often among the first signs of the contagion that manifest themselves. But in infants to which nurses having that disease communicate it by suckling them the conglobate glands of the neck are generally first invaded.

That is, the infection being absorbed by the mouth of the lymphatic veins, hastens to the glands through w: they trace & by sticking in their narrow passages so obstruct, & from its acrimony vitiates the glands that it causes them to tumify.

(EE) But it will be neither useless nor foreign to our purpose to bring examples of this kind from other diseases to illustrate the matter still further.

In inoculation of the small pox which prevails much among us, for the most part, a very small incision is made in the arm into which a linnen or cotton thread imbued

imbued with the variolous matter is put. The disease being thus artificially communicated, tumors very often arise in the axilla as we know from experience; so that they are taken for a certain sign by many that the infection (i) has taken place. And since for many years the incision has been made only in one arm, and not as formerly in both; it is also observed that in that side in which the incision is made the axillary glands turnify.

Therefore physicians imagin that they become swelled, either because the poisonous is expelled there with less force; (k) or because the incision causes a fluxion, as they choose to call it, in the adjacent parts; but these reasons are so weak that neither of them appear in the least probable; for how is it credible that the glands of the side on which the incision is made urge out the matter with less force than in the glands of the other side? Nor does this explain why they begin to turnify before the matter has produced a fever or shows its effects in the blood & heart. What? that a light inflammation that follows from so small a wound

(i) particularly by D.r Archer physician to the Small pox hospital in London. (k) v: Mead on inoculation

can in any wise be supposed to cause such a fluxion; by no means. For if we except the edges of the wound, neither the skin nor cellular membrane becomes red or swell or show any marks of inflammation or stimulus; and the incision which is generally made below the middle of the humerus is very remote from the axillary glands. There is no need therefore of having recourse to ambiguous causes: when the phenomenon can be well explained by the inhalation of the lymphatics, viz.t that the absorbed poison passing on towards the heart affects the axillary glands, thro' which the lymphatics of the superior extremities pass, & causes them to tumify.

[I.] I also once saw a remarkable example which clearly demonstrates that there are absorbent lymphatics on the surface of the head.

A certain Lady having been along time troubled with pains of the head, by the perswasion of her physician applied an epispastic to the top of her head, that it might ulcerate the skin & produce an issue. But there arose about the whole neck especially on the back part a great swelling of the conglobate glands vulgarly called wax kernels; the plaister

being taken off there uncommon tumors which were attri=
buted to the cantharides subsided in a short time. But
other medicines being made use of in vain, cantharides
were again had recourse to & with exactly the same
event. If there only the conglobate glands thro' which
the lymphatic veins of the head face were affected in this
case that must without doubt have been owing to the
absorption of the acrid irritating particles of the cantharides
& their being carried by the lymphatics into these glands.

(G G)// There are many examples related by authors of
diseases & ulcers of the extremities causing the axillary and
inguinal glands to swell. Thus in the most painful species
of paronychia or whitlow Van Swieten often saw a tumor
arising suddenly under the arm altho' the disease was
seated in the extreme end of the finger, the cause of which
he imagined was the glands being placed in very soft fat,
free from any compression of the muscles, &c. Dr. Russel also
observes that the inguinal glands swell from diseases of
the legs and thighs which he supposes is from some sympathy.

and Dr. Reymarus who has wrote a learned dissertation de fungo articulorum or white Swelling as its commonly called but in which is contained many judicious observations, every often saw himself the inguinal glands swell if this disease had invaded the knee, which shortly disappeard after amputating the limb. From what we have now said it can scarce be doubted but that these tumors proceed from the absorption of the lymphatic veins.

From these examples it appears that there are valvular absorbent lymphatic veins arising from the surface of the head, from the cavity of the mouth, from the breasts, from the extremities of the body & from the genitals. We have moreover brought various arguments by which we have endeavored to show not only the weakness & improbability of that doctrine which supposes lymphatic arteries answering to these veins; but also that the experiments themselves adduced for that purpose, the various appearances of these vessels, their fabric, particular course, their analogy with the lacteals, the simplicity of nature, & the constant similarity of them, all conspire to prove that

Of the Lymphatics

that the valvular lymphatic vessels thro' the whole body are a system of absorbing veins.

Conclusions

As anatomy ought to be subservient to the practice of physic it may not be improper to subjoin some consectaries.

(a) Some Surgeons strenuously assert that a virulent gonorrhaa & the lues venerea which affects almost all the parts of the body as well as the genitals differ entirely in their nature, & that the former is never converted into the latter. They are also in doubt to which of these two a bubo ought to be referred. But it appears, from what has been said, that a bubo is the effect of the contagious matter taken in by the lymphatics & obstructed in the conglobate glands. From which then is demonstrated the connection there is between a virulent gonorrhaa & an incipient pox, as this is as it were in the middle between the two. For if all the morbid matter accumulates in the obstructed gland & is ejected by a supervening suppuration the patient escapes & is free from the pox. But if it does not all adhere to the obstructed gland; or, if the bubo is discussed

i,e. if the poison continues on & enters thro' the lymphatics thoracic duct into the blood, the infection will be communicated to the rest of the body when the patient is said to have the pox. It seems strange therefore that a thing that is proved by every days experience should be called in question.

(b) The Lues venerea as we see often enters the body thro' the lymphatic veins; & frequently stops in the conglobate glands which these vessels enter. Mercury seems to cure this disease not by increasing the momentum or velocity of the blood, nor by its effecting the morbid particles, but by a specific virtue if we may credit the authority of some practicioners. Hence it would perhaps be by no means useless to apply mercury & mercurials to the place primarily affected which by entering the vasa lymphatica might perhaps weaken or entirely destroy the virus of the poison before it could enter the blood

(c) Almost all physicians attempt the suppuration of a bubo rather than a resolution of it, as the latter is found by experience to threaten the patient with the pox. But some late surgeons that they might cure their patients more speedily & with less inconvenience have attempted to cut the bubaes. And indeed

if this operation is cautiously performed, carefully avoiding the adjacent arteries & veins, & before the glands are greatly enlarged, it will not only be less tedious & painful, but there is less danger of the contagion extending any farther, for it both takes away the matter & prevents the further spreading of the poison. This would be particularly beneficial if the ulcers were cancerous which always exasperate the disease.

(d) A frequent observation occurs among authors who have treated of the plague, viz: that pestilential buboes &c terminate in suppuration are very salutary. And, if the unexpected eruption of tumors of this kind affords us the first sign of infection in the sick person as both the french & other medical writers of veracity assure us, (n) then it appears very probable that this disease proceeds from the absorption of the pestilential matter by the lymphatic veins: if so it seems likely that an extirpation of these glands would be of great service. For by extirpating them the pestiferous matter hesitating in these glands might be taken away; & it would prevent any more of the same from mixing with the blood, at least by those passages, and by

(n) See Mead on the plague.

making a drain or ulcer the body might thereby freed from those noxious particles that ofs. perhaps already mixed with the blood.

(e) It is obvenied that the pleague oftener affects the glands of the face, neck & superior extremities, than those of the groins & inferior extremities, owing perhaps to the latter being less exposed to the air. Hence it would seem that keeping the body well covered would prove serviceable in the cure of the pleague.

(f) It seems a probable conjecture that unction of the body which stops up the mouths of the lymphatics and herbyfs also the contagion of the lues venerea & pleague as far as they are received by the external skin from infecting us.

(g) The receiving the small pox in the natural way, with many other things prove that this poison penetrating in the air is taken into the stomach & lungs where lying it may excite very dangerous inflammations & obstructions; but by inoculation the organs of less importance and substances are first affected before it enters the blood

Hence the virus more rarely attacks the more noble organs but hastes to the skin which seems to be more affected by this disease than the other parts.

(2) The inoculation of the small pox which has founded so happily is unknown to none. But the inoculation of the measles I am fully persuaded would be attended with much more happy & useful consequences. For its too well known that this disease is very apt to affect the lungs & from thence causes much havoc. This seems to be owing principally to the contagion flying in the air being first taken into the cellules of the lungs in inspiration, to which it firmly adheres, inflames them, and excites a cough or an endeavour of nature to drive off the noxious matter. But if the measles should be brought on by inoculation it seems very probable that the lungs would be more free from inflammation & that the disease would for the most part only affect the skin. If it should so happen of how much advantage & utility would it be to the human species? The experiment can be

attended with no damage or inconvenience. It is probable that the disease may be communicated, if only the pustules or mature ulcers, are rubbed with cotton & then this either recent, or preserved in a vial closely stopped, be put into a small wound exactly as the variolous matter.

(i) The Scrophula in a particular manner occupies the conglobate & lymphatic glands. Hence external deobstruent & stimulating medicines are reckoned to be particularly useful in this disease which penetrate, by the resorption of the lymphatics almost unchanged to the very seat of the disease, & from thence they more properly stimulate the solids & more efficaciously alter & correct the morbid matter than the remedies commonly exhibited internally which are conveyed by long winding vessels weakned & altered at length to the parts affected.

(k) Lastly, in all affections of the conglobate glands external remedies should be made use of much more frequently than they are.

Circulation of the blood

The vessels which we have hitherto described whether arteries or veins contain either blood or lymph; we have not as yet examined either the quantity or nature of those liquors, both of which will be done in its proper place. We shall only here observe that both the arteries & veins are always full with their humors whether blood or lymph in a living animal as well when they are greatly distended with their fluid as happens in their diastole, a plethora or from other causes, as when they appear collapsed from cold fear or other causes. And indeed the red arteries continued from the heart in like manner contain blood & not any thin humor, spirit or air as Praxagoras first taught, then Erasistratus who were followed by Cicero, Aretæus, Rufus and others, but Erasistratus was the most strenuous asserter of this doctrine. In opposition to him Galen made many experiments for which he well deserves the thanks of posterity. He shows that no artery could be opened in the living body but blood would immediately rush out, & that a great

quantity of blood was always found in the left ventricle of the heart, contrary to what Erasistratus had taught.

To account for this Erasistratus had supposed it to be owing to the pain & struggling of the animal whilst the vein was taking off which occasioned the blood to flow from the veins in the vicinity of the wound into the arteries by their anastomoses.

But Galen likewise refuted this assertion by Experiment for though he first tyed the arteries so that blood could not flow into them from other parts, yet upon opening them, it was found they contained blood as before. Besides the rapidity with which the blood flows from a cut artery is greater than the velocity with which it flows from open veins. And when we view the arteries of the meventery in the smaller animals we may with the assistance of glasses, & often even with the naked eye see the motion of the blood through the arteries.

On what Erasistratus chiefly founded his opinion is difficult to say; perhaps it was on the necessity of air to animal

life which he might suppose circulated in the body as the blood in a particular set of vessels. The air is taken in at the lungs from whence he might suppose it to be conveyed by the pulmonary artery to the heart. & from the heart by the aorta to the rest of the body. He might be led to this perhaps from the theory of the ancients who speak much of an air or spirit predominant in the body & overruling its motions as we sometimes talk of a subtle ether pervading & actuating matter. The whiteness of the arteries too might mislead him, as he could not readily discover the red blood through their thick & cellular membranes or coats as he could in the veins.

Nor is air seen in the arteries at any time more than in the heart & veins, which when it is found is consequent upon putrefaction taking place in the body & which is increased with the increase of putrefaction, & that only takes place when the air of the blood is expanded by heat. Air bubbles which are sometimes seen in cold

animals are rare nor do they belong to their fabric con-
stantly & perpetually; they seem to have got into the
blood by some wounds, seeing they are not discovered
when all the parts are preserved in an entire sound state
nor are the arteries empty after death. This is
proved by dissection. Harvey has rightly observed that
there is less blood found on opening a dead body in the
arteries & in the left ventricle, than is found in the
veins or in the right ventricle; this has been confirmed
by a variety of experiments & observations, seeing the
arteries contract themselves by dying, by the pressure of
incumbent bodies & the force of the cold as well as
the attraction of the cellular threads of which they are
composed, as proved by late experiments they contract
to 2/9 of their former capacity; and Harvey confesses
that he has found blood in the arteries of some he
opened after death who had been suffocated or dyed
in a swoon

Circulation of the blood

It is true that the veins are more turgid with blood than the arteries, for the arteries being more dense & firm more easily get rid of the blood that was in them: the veins must receive & are obliged to retain it, since the heart by its weight resists: besides if it did not resist, yet it could not contain but a few ounces. Hence in the larger trunks & in the vena cava near to the heart the greatest quantity of blood is always found, espiially in strangled & apoplectic cases.

That there is a communication of all the blood vessels in the body whereby the blood may be drained from the whole system by means of a wounded artery or vein of any considerable size appears from numberless experiments & obsepvations

That the blood flows from the heart into the trunks of the arteries, from the trunks into the branches, & from the branches into the small capillary vessels is undoubted, as the blood is never at rest in the vessels of a living healthy animal

That it flows from the heart into the arteries may be proved by the application of bandages or ligatures upon arteries Should we tie a ligature upon the aorta, the carotid, pulmonary brachial or crural artery or any other we should see by the

means the part of it that was intercepted between the heart & ligature would be filled & grow turgid with blood, that it would look blue & spring out with great force whenever it should be pricked between the heart & ligature. On the other hand the same arteries would become empty & grow pale & smooth beyond the ligature, & upon being opened in that part would not emit blood. Again, upon loosing the ligature the blood would rush into & fill that part of the artery as before so as to restore its former pulsation and capacity & blood would gush out of the wound.

These experiments have been often repeated by Vesalius Harvey, Morgagni, Haller & others and always with the same results.

It is the constant practice of surgeons to compress the artery in case of large hemorrhages & in aneurisms, or to tye up the artery between the seat of the disorder & the heart so as to intercept the course of the blood from the heart to the wound or aneurism, to prevent or cure the hemorrhage in the first case, & guard against the too great dilatation

of the artery in the false aneurism. We read of a violent hemorrhage or bleeding of the nose being checked by compressing the carotid artery. Whenever the remote part of an artery is rendered impervious by an inflammation or any other cause, the artery above the obstruction is dilated by the blood rushing into it as are likewise the collateral branches between the obstruction & heart.

It is no objection to the truth of this that the blood sometimes gushes out from an artery below the ligature with great force, e.g. In the arm, where a ligature should be made round the artery on account of an aneurism in the brachial artery, the blood might rush out beneath the ligature pet vattern upon being cut or divided by the hand of a surgeon unless a ligature was also applyd on the inferior extremity of the divided artery, because the artery above may have detached branches from above which are not included in the former ligature that communicate by anastomosis with the part beneath. Such accounts are given by Cheselden in Le Drans operations of surgery & in Sharp's surgery.

Sometimes some of the mesenteric arteries have been inclosed in a ligature without occasioning any tumor in that part above or being more than commonly filled with blood, this is also owing to the frequent anastomosis of the vessels in those parts.

That the blood passes from the heart into the arteries even the smallest is confirmed also by the testimony of the sight. It is very easy & beautiful to see the blood rushing in a torrent from the heart into the arteries when we examin the naked mesentery of a frog, or the transparent tales of small fishes, which direction of the circulation is continued to the smallest extremities of the little branches as long as the heart retains its usual force & strength.

It is certain indeed that in dying animals the motion of the blood is sometimes inverted in a part from an irregular motion in the system & from the heart's failing in its strength.

This same retrocession of the blood frequently takes place in a part when the blood stagnates in the very small arteries, & the force of the heart is so diminished as to impel

the blood forward with less force than the resistance it meets with. The blood then begins to oscillate & to flow in an alternate direction, one while from the heart towards the extremities of the small arteries; then again in an opposite direction from those extremities towards the heart, until a perfect rest succeeds or till the obstacle is overcome, & the force of the heart gaining the ascendancy restores the native course of the blood.

So long however as an animal enjoys life & health so long is the course of blood from the heart to the arteries continued. It must be a disease, a weakness of the heart, or some insuperable obstacle which forces the blood in the arteries back towards the heart.

But it would not be just to draw arguments from diseases & the beginning approaches of death against those phenomena which are observed to take place in a sound & healthy animal

The course of the venous blood. The ancients were wholly ignorant of the true direction & course of the venous blood. They supposed the direction of it to be the same with the arterial blood. They imagined that the blood flowed

through the vena cava ascendens & descendens from the heart to the extreme branches. They supposed however this differene that the vital spirit flowed through the arteries and the nutritious blood through the veins to all the extremities of the vessels & to the whole body. From so memorable an example of a universal error of the ancients, we should be on our guard not to recieve a thing for truth only because it is a commonly recieved opinion, but we should make experiments whereby to confirm our opinions.

Ostenditur a valvulis. The blood which is conveyed to all the body from the heart by means of the arteries, is collected from all the extreme parts by the small branches of veins & returned again to the heart.

The offici & structure of the valves is sufficient to prove this to be the true course of the blood. It is a wonderful example of the force of prejudice in opinions that Hyeronimus Fabricius in his book De ostiolis venarum should have described and depictured the valves in the arm under aligature fastened about the arm quite timid. & yet that he should not discern

that they never would have swelled in that manner if the blood came to them from the heart, for the ligature was sufficient according to his hypothesis to have kept the blood from coming to the hand. He had made the experiment & seen that the blood yielding to the impulse of the finger in stroking the veins of the arm upwards proceeded towards the heart; and on the other hand by attempting to force it downwards the valves resisted its progress & swelled into knots: so that by this experiment, he was led by the hand, as it were, to the knowledge of the valves. Yet he could discover nothing in that structure, but as he imagined the cause of the delay in the motion of the blood, & the precaution of nature to prevent the blood being carried from the vena cava to the extremities of the body with a too rapid by the action of the muscles.

But the wise Herveus well considering the structure of these valves observed that the blood in its course from the extremities of the body, striking on the convex surfaces of these valves would press them against the sides of the

veins & so make a free passage to itself: whereas, if the blood should be impelled from the heart thro' the veins to the limbs it would strike on the hollow sacks of the valves, & so carry them to the axis of the vein as to shut up the passage to itself, or at least so as to straiten it very much.

Father Paul Sarpi a venetian monk is said to have better understood that the blood could not pass the valves from the heart to the extremities, & an attention to this was the cause of his finding out the valves teaching us their true uses.

If the valves were wanting the action of the swelling muscles compressing the veins might be considered as being divided into two equal parts: the first would impel the blood towards the heart, the other would drive it back towards the extremities of the limbs & would resist the return of the blood from the surface of the body to the heart. By this means the action of the muscles would do as much hurt as good to the circulation of the blood. For there can be no reason assigned why the venous blood would

not there be forced by the muscles to the surface of the body as much as to the heart. But now that there are valves the whole muscular action whereby the veins are compressed only assists the circulation of the blood. all the force is preserved by which the blood is impelled towards the heart, but that part of the pressure which would be injurious or contrary to the return of the blood is supported by the valves. Hence it is that the veins in the limbs are plentifully furnished with valves & those of the viscera have none, because the limbs have muscles whose action can contribute to the blood's circulation.

As to the use of the valves: besides their being assistant to the circulation, it is their most peculiar office to support the incumbent weight of the blood.

In a man whose posture is that of sitting, & more so if it is that of standing, the blood in the vena cava & crural veins would not go to the heart with sufficient force to prevent its falling down to the feet (if there were no valves to support it) if that posture of the body should be very

long continued, or if there should be a greater quantity of blood, or a greater weakness of body, or a difficulty & obstruction should happen to the returning blood; hence preachers & gravid women are so subject to varices of the veins, hence those persons are subject to oedematous swellings.

To understand of how much service these valves are in lessening the danger of the blood's falling down to the feet by the force of gravity, let us for a moment suppose there was but one pair of valves from the feet upwards, dividing the blood into two columns: Should this pair of valves prove of no service at all, the upper column would by its gravity press on the inferior one, & as it retains but little of the force given it by the arterial blood, it would be pushed back instead of forward, but by the medium of the valves the superior column is sustained & kept from pressing on the inferior one, & that so much the more as the valves are very numerous.

The true course of the venal blood is also proved by Ligatures. In the common practice of blood letting

it has been always usual to tye up the arm between the heart & that part in which the vein is to be opened. It may now seem strange to us who know the matter well, how it happened that this simple experiment was not sufficient to free the ancients from their error. For, if the blood flowed from the heart to the extremities of the body thro' the veins, then the ligature would intercept the blood between it an the heart & would keep it from coming below to the vein where it was the intention to draw blood, & no blood could be got there; whereas a ligature between the heart & place of incision causes the vein to fill, to grow turgid & pour out blood copiously. It was easy from this to draw this inference that the blood came from the hand, not from the heart. Andreas Cæsalpinus was the first however who saw the force of this experiment. He seemed to stumble on the truth in part, which Harvey afterwards made a better & full use of. It was objected indeed that if the arm was tyed very tight the bleeding would

be wholly, or at least in a great measure stopped, & if the ligature is loosened the blood will again flow out in a stream. This was easily answered by Harvey who shew'd that by a tight ligature, not only the veins but likewise the arteries would be compress'd which would fully prevent the blood from coming at all to the lower part of the arm & the pulse to beat till this impediment should be taken off, on which the blood would flow again as before.

Similar to this argument is that taken from a ligature upon the jugular veins: the face swells the tunica conjunctiva of the Eye becomes quite red & a bleeding at the nose ensues. But nothing of that sort could happen if the blood came to those parts by the veins directly from the heart, for the ligature would keep it from the face instead of accumulating it in the head. This shews that the course of the blood through the veins is towards the heart. The course is further proved by the use of ligatures apply'd to the joints to stop an hemoptoe or a profuse spitting

of blood, or flooding, and hemorhages of the nose.

Diseases such as polypi & other tumors which compress the veins & impede the free passage of the blood will prove the same thing.

Nor is it any objection that blood may be collected sometimes above the ligature & flow out upon opening it, seeing there are in those instances a number of veins which as branches empty themselves into the vein w.ch is bound up as into a trunk & therefore there is nothing unexpected. The same thing may be given as an answer if it be alledged that sometimes a vein that is opened between two ligatures discharges blood freely. This is on account of the branches of veins which empty themselves into the vein that is tyed up above and below. On the same account the eyes sometimes do not swell on binding down the jugular veins because there are many others quite free that run deeper, into which the vessels of the eye can readily enough discharge themselves.

Circulation of the blood

This course of the venous blood is likewise proved by ocular demonstration by the assistance of microscopes.

Having shewn that the blood passes from the heart thro' the arteries to their smallest branches, and the veins from the smallest size to the larger trunks from the extremities of the body; we shall now further shew that the arterial blood coming from the heart passes from the arteries into the veins, and from the veins is returned to the heart.

Little is now required to demonstrate the circulation of the vital fluid. It has been shewn when upon the subject of arteries & veins that the extremities of the arteries communicated with the incipient veins, and in what manner. If then the blood is carried from the heart through the arteries into the smallest arterial branches; if these small branches communicate with the small veins; if the veins return the blood from the extremities of the body towards the heart, the whole course of the blood from the heart through the arteries &

veins to the heart again seems to be proved. But as this is a matter of the greatest consequence, & deserves to be thoroughly understood, it behooves us to collect further arguments on which we may establish the basis of the true theory of Physic.

A little reflection on this matter seems as if it would lead us to the truth. Seeing the blood is carried with great velocity through the arteries to their capillary branches, it must necessarily pass either into other vessels, unless it passes out, it must stagnate, collect, distend & burst the vessels. But it does not pass either into lymphatic or exhaling vessels, or into excretory ducts, for the humors contained in these vessels are different from the blood; it only remains that it must pass into the veins.

Again, the veins convey the blood towards the heart, it follows then that they must receive it from some place; but they do not receive it either from lymphatic or inhaling vessels; it remains then that the veins receive the blood

from the arteries which are known to convey blood and to be continuous (or communicate) with the veins.

Further, if a liquor impelled into the arteries in the same direction as the blood is, can, & does pass into the veins, (as proved by injection) it follows that the blood drove from the heart by the arteries in the same direction must necessarily pass into the veins. For the vessels are the same (whether we speak of the liquor injected by the anatomist, or of the blood & the direction is the same), nor does the different color or different kind of fluid avail ought in changing the course of the blood.

But these are not the only arguments we can employ in proof of the circulation.

We can further prove it true by a ligature of the arteries. As we mentioned in the case of bleeding if an artery is tyed or compressed the corresponding vein receives no blood, but if the artery be loosened the vein is filled again with blood & vents it copiously from the wound.

Circulation of the blood

The experiment has been tryed in the canal vessels, those of the mesentary, the spleen, & the liver. This proves that the blood flows immediately from the artery into the vein, & that the vein has no blood but what it recieves from the artery.

If at any time when the branch of an artery is compressed, the vein with which it communicates is still supplyed with blood, that must proceed from some other artery likewise communicating with it, or with some other vein with which it anastomoses.

Moreover, if the blood vent out from the heart did not return to it again, it would soon be exhausted of all its blood. So great is the quantity of blood continually vent out from the heart by means of the arteries that it would be impossible for a wounded man to live for many minutes, if, in the place of the blood discharged by the arteries a supply was not furnished to the heart from the veins. But let us attend to this experiment

and to observation a little more closely. The left ventricle of the heart contains about two ounces of blood more or less; the whole quantity of which in a healthy person is discharged from the heart in every systole or contraction of the ventricle, that is, every pulse & the ventricle becomes quite pale as well as empty. If any remains behind it is certainly very little in each ventricle at the rise of the heart on each contraction; for the heart would not be quiet, if it was stimulated by any quantity of blood, neither can any remain in those animals whose hearts are transparent, or in the chick, which is contain'd in an incubated egg until it is quite pale after each pulsation; or, if some blood does remain after each pulse it will still amount to the same, for in a second pulsation it must be discharged, so that there would be no more at least remaining after the second pulse than after the first, & so much of the old blood remaining after the first pulse would be discharged after the second as remains

after the second pulsation of the new blood, so that two ounces would still be thrown out at every pulsation. for if we suppose the contrary & allow that a greater quantity remains after the second pulse than the first. a drachm for instance, then after 1000 pulses a thousand drachms of blood will remain in the ventricle which is absurd since both ventricles of the heart taken together with the auricles are not of a sufficient capacity to contain half that quantity; we affirm then that the whole two ounces of blood are sent from the heart into the aorta after each pulsation. Eighty pulses are counted during the space of one minute in many persons, who are in an indifferent good state of health. This will make the computation 4800 ounces of blood which is sent every hour into the aorta & which is from thence conveyd into the arterial system. So that in the space of one natural day 14400 pounds of blood is the quantity which is discharged from the left ventricle of the heart

Suppose now that the same healthy person rested

take 120 ounces of meat & drink together in the space of 24 hours, although indeed there are few persons whose appetite would enable them to do this. A great many ounces of this passes off by various outlets of the body as excrementitious, & much by insensible perspiration, yet, let us grant that all the meat & drink should be chang'd into blood, still there would not be any kind of proportion in the food to the blood, & it would require 600 days food to make as much blood to supply the heart with, as the heart would expel in one day.

It follows then, that the blood which the aorta receives from the heart returns again to the heart, but that must be by the veins, for there is no vessel of a different nature which is connected with or terminates in the heart. It is necessary then that the same quantity of blood which is discharged from the heart and received into the arteries should pass into the veins and be returned by them to the heart. This argument

alone

as it is simple & void of all artifice, ought to fully satisfy every man who is a lover of nothing but what is truth.

Let these proofs then suffice for the present; if further arguments are required, they may be drawn from wounds, poisons communicated to the blood by the veins by absorption, by injections of medicines into the veins or infusions, and the history of the transfusion of blood.

But to put the truth of the blood's circulation beyond all dispute it is proved by ocular testimony.

After what has been said to demonstrate the circulation of the blood nothing more can possibly be required than ocular demonstration; and this at last we have been happy enough to attain, but not till since the death of Harvey.

After the opposition that was made to the discovery & the unreasonable objections that were raised to it from ignorance, envy, or prejudice we had no room to hope we should ever be able to keep clear from all cavilling without this finishing stroke. But now we may hope it is put beyond all doubt, & that it must be acknowledged as a physical axiom — Since

anatomists are now able by the assistance of microscopes to see the blood pass from the extremities of the arteries into the veins. Marcellus Malpighius in the year 1661 publish'd experiments which he had made by the assistance of a glass lens in the lungs, mesentery, and urinary bladder of frogs, in all these places he saw the blood issuing out of the arteries & continued to the veins, by a true inosculation of these vessels, and he likewise saw it carryed back in the same manner in a contrary direction in the veins.

Lewenhoeck a citizen of Delph in Holland a man not educated in physic, but very skilful in polishing of glasses entirely cleared up every doubt in this matter.

In the year 1680 he did not yet know that the veins were continuous with the arteries, and assumed in his writing that the veins absorbed the blood which was poured out from the arteries. Afterwards from about the year 1668 he saw by his glasses in various animals having a pellucid skin the blood moving from the heart along the arteries to their extremities & to proceed from thence along the veins

to the heart; and he described the apparatus proper for repeating those experiments. He saw the artery reflected and the reflected part now become a vein, run parallel with the artery, & the blood flowing along the vein thus return to the heart. He likewise saw the arterious branch, let in as it were to the neighbouring vein & the artery divided into two or three branches which all became confluent again and united into one small vein.

Again he observed that in a somewhat different manner the blood passed from an artery into a neighbouring and parallel vein, by means of communicating branches. This is indeed a very difficult matter, & an object that may easily mislead one, as it is very easy to mistake small veins brought into a reticular work for arteries; besides the area of the microscope is small, & the vein may creep along for a considerable distance so as hardly to be known from an artery.

After Lewenhoeck, microscopical observations were made by many other persons very frequently; and first by Willis for Cowper in a young kitten, in the mesentery of a

dog, & in the omentum of a cat.[x] He has in a most happy & rare manner delineated a reticular work of small arteries & veins inosculating with each other. This is a most difficult & uncommon matter to be able to demonstrate in animals having warm blood. Lewenhoeck could only do this in a bat, and that with difficulty & not so perfectly; for the contact of cold air immediately coagulates the blood of such kind of animals and stops its motion.

The learned Cowper has delineated the communicating branches of the arteries & veins in small fishes & larger anastomoses of both these kinds of vessels in the lungs of a frog than in other animals; and the same also in the foot of a frog for which see his appendix to Bidloo's works

In the philosophical transactions N°. 288 the circulation of the blood in the tail & gills of a water lizard is depicted by Molyneux.

Cheseldon in his anatomy gives an account of the arteries reflected into veins, & of the insertion of the lateral branches & likewise gives a plate in which is expressed the

area in which the circulation is performed Tab: 3 fig 3: of Edit.r VI

Baker in his microscope made easy, has also given a figure of the vascular network in the foot of a frog. He likewise informs us that we need not make use of the most convex glasses for this purpose.

The celebrated Hales likewise viewed the circulation of the blood in the lungs of a frog (vide his hæmastatics p. 66, 150 & seq:) this he did as the blood was in its passage from the extreme ends of the arteries into larger veins. in which they were inserted at right angles. He likewise confirms what had been advanced that several small arteries unite into one vein, (vide p: 70).

Anthony Deleyde by the help of his microscope saw the blood circulating by an intermediate plexus of arteries and veins. Joblot saw another kind of circulation w: happened between branches arising from the arteries at various angles & likewise inserted at various angles into parallel veins.

The retrograde motion that has been observed is no objection as it denotes a violent disease a the approach of death.

Circulation of the lymph

Let us now speak a little of the circulation of a lymphatic fluid finer than that of blood: for if we except those useless humors which are discharged from the living body all the circulating fluids return to the mass of blood from whence they were separated. But as few other vessels are known besides the arteries & veins already treated of, only the lymphatics, we shall confine our enquiries to those vessels.

Since the first discovery of these vessels almost all anatomists have agreed in describing the course of them to be directed towards the thoracic duct: that is, the lymph flows from all the circuit of the body & from small pellucid branches into the larger lymphatic vessels & their trunks, & lastly into the thoracic duct which empties its contents into the left subclavian vein as it brings the returning blood to the heart. There are indeed some of these lymphatics which empty themselves into the veins in other places. Thus the lymph circulating with the blood thro' the arteries is carried to every part of the body. It is probable that part of it exhales from out of the body & part passes into adjacent glands.

but the greatest part of it is returned by the lymphatics into the thoracic duct thence into the red veins & so to the heart.

Ostendunt vincula. By means of ligatures Bartholin always rendered the lymphatic vessels conspicuous; he constantly saw in whatever part of the body these vessels were tyed so as to stop the course of the lymph, that they always swelled between the ligature and their very small roots & that on the contrary the part intercepted between the ligature and the thoracic duct always became empty, or, at least the part intercepted between the ligature & red veins into which it emptyed itself. Hence it follows, as was shewn in the blood, that this pellucid humor flows from the whole body either into the thoracic duct or into the red veins, & that being stopped in its course by a ligature the smaller branches from whence the lymph come will be distended. These experiments have been often repeated by other able anatomists. Hence by following the advice of Rudbeck & tying the thoracic duct itself with a ligature these pellucid vessels are most beautifully demonstrated, seeing the fluid which

is brought this way being stopped by the ligature distends its vessels. And often by tying the red veins, as the jugular and especially the trunks of the vena portarum, the neighbouring lymphatic veins grow turgid, whether they communicate with the sanguineous veins of the part or whether it is because they are comprehended with the red veins under the same ligature.

valvula. This opinion received a greater degree of certainty after Swammerdam & Ruysch had delineated the valves of these veins. It thus plainly appeared that these valves had the same structure & performed the same office with the valves of the sanguineous veins; the sinuses of them being opened towards the thoracic duct & the heart & their convex parts towards the origin of these vessels, therefore the lymph striking on these convex parts in its course from the small roots of these vessels would press the valves against the sides of these vessels & no way impede the course of the lymph towards the thoracic duct, but would hinder its passing in a contrary direction, in the same way that the valves in the red

red veins prevent the regress of the blood in its circulation through them. Air injected in the course of the lymphatics will easily pass through the thoracic duct to the heart, but the valves prevent its passage in a contrary course; If perchance the air or any other fluid injected into the lymphatic vessels in a contrary direction should escape one or two of the valves from their not being quite so close, as in the larger veins, yet it would not proceed thro' many of them before it would be quite stopped.

The lymph thus conveyed by the thoracic duct & the veins into the heart, must pass by the arteries to every part of the body in which it is separated from the blood, chiefly to keep all the parts moist, and is taken again into the lymphatic system to dilute the chyle the useless part being carried off by the proper secretions.

Thus we have given an idea of the circulation of all the humors.

PHYSIOLOG